ISSN 0110-1749

Fisheries Research Bulletin No. 27

The Enoploteuthidae (Cephalopoda: Oegopsida) of the New Zealand Region

LIBRARY

FEB 20 1986

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

by
D. J. Riddell

Fisheries Research Division
New Zealand Ministry of Agriculture and Fisheries

Fisheries Research Bulletin No. 27

The Enoploteuthidae (Cephalopoda: Oegopsida) of the New Zealand Region

by
D. J. Riddell

Department of Zoology
University of Auckland*

*Present address: Gordonton Road,
R.D. 1, Taupiri, New Zealand

Fisheries Research Division
New Zealand Ministry of Agriculture and Fisheries
1985

Published by the New Zealand Ministry of Agriculture and Fisheries
Wellington
1985

ISSN 0110-1749

MAF Libraries cataloguing-in-publication data.

Riddell, D.J.
The Enoploteuthidae (Cephalopoda: Oegopsida) of the New Zealand region / by D.J. Riddell.

1v. (Fisheries research bulletin, ISSN 0110-1749 ; no. 27)

1. Cephalopoda 2. Squid

ISBN 0-477-03100-5

Edited by J. L. Taylor and G. G. Baird

Set in 10 on 11 Plantin

CONTENTS

	Page
ABSTRACT	5
INTRODUCTION	5
GENERAL MORPHOLOGY	5
AREAL AND VERTICAL DISTRIBUTION	6
PREVIOUS WORK ON THE ENOPLOTEUTHIDAE IN NEW ZEALAND	6
MATERIALS AND METHODS	7
ABBREVIATIONS, FORMULAS, AND INDICES	7
SPECIES DESCRIPTIONS	8
Genus *Ancistrocheirus* Gray, 1840	8
Genus *Pyroteuthis* Hoyle, 1904	10
Genus *Pterygioteuthis* Fischer, 1869	15
Genus *Enoploteuthis* Orbigny, 1848	22
Genus *Abralia* Gray, 1849	31
Genus *Abraliopsis* Joubin, 1896	37
KEY TO THE NEW ZEALAND ENOPLOTEUTHIDAE	47
FEEDING	48
ACKNOWLEDGMENTS	48
REFERENCES	48
APPENDIX 1	50
INDEX TO SPECIES	52

FIGURES

		Page
1.	Sites in the New Zealand region at which enoploteuthids have been collected	7
2.	*Ancistrocheirus* sp., ML 21.2 mm	9
3.	*Pyroteuthis serrata*, ML 29.7 mm, male	12
4.	*Pyroteuthis* spp. parts	13
5.	Distribution of *Pyroteuthis* spp.	14
6.	*Pyroteuthis margaritifera* parts	14
7.	*Pterygioteuthis giardi*, ML 18.2 mm, female	16
8.	*Pterygioteuthis giardi* parts	17
9.	Distribution of *Ancistrocheirus* sp. and *Pterygioteuthis* spp.	18
10.	*Pterygioteuthis gemmata*, ML 31.0 mm, female	19
11.	*Pterygioteuthis* spp. parts	20
12.	Number of hooks on lateral arms of male *Pterygioteuthis microlampas* and *P. gemmata*	21
13.	Number of hooks on lateral arms of female *Pterygioteuthis microlampas* and *P. gemmata*	21
14.	*Enoploteuthis galaxias*, ML 59.3 mm, male	23
15.	*Enoploteuthis galaxias* parts	24
16.	Distribution of *Enoploteuthis* and *Abralia* spp.	25
17.	Distribution of *Enoploteuthis galaxias* in Bay of Plenty	25
18.	*Enoploteuthis reticulata*, ML 45.4 mm, male	26
19.	*Enoploteuthis reticulata* parts	27
20.	*Enoploteuthis reticulata*, ML 17.2 mm, juvenile	28
21.	*Enoploteuthis ?jonesi*, ML 11.6 mm, juvenile	30
22.	*Abralia astrolineata*, ML 52.0 mm, female	32
23.	*Abralia astrolineata*, ML 17.8 mm, juvenile	33
24.	*Abralia astrolineata* parts	34
25.	Distribution of *Abralia astrolineata* along Kermadec Ridge	35
26.	*Abralia* n.sp., ML 28 mm, female	35
27.	*Abralia* sp. B, ML 13.8 mm, juvenile	37
28.	*Abraliopsis tui*, ML 30.2 mm, female	38
29.	*Abraliopsis tui* parts	40
30.	Distribution of *Abraliopsis* spp.	41
31.	*Abraliopsis gilchristi*, ML 35.4 mm, male	44
32.	*Abraliopsis gilchristi* parts	45
33.	Distribution of *Abraliopsis gilchristi* in East Cape region	46

TABLES

		Page
1.	Measurements of *Pyroteuthis serrata*	11
2.	Measurements of *Enoploteuthis galaxias*	25
3.	Measurements of *Enoploteuthis reticulata*	29

ABSTRACT

The enoploteuthid squids collected from the New Zealand region by Fisheries Research Division (of the Ministry of Agriculture and Fisheries) and the Auckland University Zoology Department are described. Fourteen species are recorded from tropical and warm temperate waters from the Tropic of Capricorn to 42° S. Two new species in the genera *Abraliopsis* and *Pyroteuthis* are described. *Pterygioteuthis microlampas* is confirmed as a valid species. The male of *Abralia astrolineata* and the developmental changes of *Enoploteuthis galaxias* are described for the first time. *Enoploteuthis neozelanica* Dell is reduced to a synonym of *Abraliopsis gilchristi* (Robson). An identification key and some information on feeding are also presented.

INTRODUCTION

The Enoploteuthidae are small to medium sized squids which are common in tropical and warm temperate seas. Only one species, *Watasenia scintillans* (Berry) of Japan, is commercially important (Clarke 1966), though the much larger *Ancistrocheirus lesueuri* (Orbigny) might be potentially important if an efficient means of catching it could be devised (Voss 1973). The importance of the family lies rather in the role its species play in oceanic food chains. They have been reported from the stomachs of a wide variety of large oceanic predators, including whales, dolphins, seals, fish, and sea birds (Clarke 1966, Rancurel 1970, Imber 1973, 1976). The extensive surveys of Fisheries Research Division (FRD) of the Ministry of Agriculture and Fisheries have revealed that several species of enoploteuthids are present in northern New Zealand waters and that some are very common. Until now almost no work has been done on the New Zealand representatives of the family. This study delineates all of the species collected by FRD and presents all the available information on their distribution and feeding. Much work, particularly on reproductive biology, ecology, and vertical distribution, remains to be done.

GENERAL MORPHOLOGY

Except for *Ancistrocheirus*, which is known to reach a mantle length of 390 mm, all enoploteuthid squids are small. Some *Enoploteuthis* species may approach 120 mm in mantle length (pers. obs. and Burgess 1982), but at the other end of the scale *Pterygioteuthis giardi* never reaches a mantle length of more than 20 mm (Clarke 1966). The arms bear two rows of suckers, some (usually most) of which are modified into hooks. The armature of the clubs is tetraserial, though the marginal suckers of the manus may be lost. There are two rows of suckers and pads in the carpal cluster. Hooks are present on the clubs of all species except those in the genus *Pterygioteuthis*. Photophores are numerous and complex in all species, though their arrangement and structure vary considerably. The gladius is a distinctive, feather-shaped structure (see Fig. 29d). The buccal membrane is eight-parted, with the ventral connectives attaching to the dorsal borders of the ventral arms. One or both ventral arms are hectocotylised in the males.

Pfeffer (1912) designated three subfamilies, which are well defined and widely accepted (Roper, Young, and Voss 1969). The Enoploteuthinae, containing *Enoploteuthis*, *Abralia*, *Abraliopsis*, *Watasenia*, and *Enigmoteuthis* (only doubtfully distinct from *Abralia*), are characterised by the presence of many small photophores embedded in the ventral surface of the mantle, head, and arms, larger photophores on the eyeball, and concave posterior borders to the fins. Nidamental glands are absent and are replaced by ovidural glands. In the past, *Abralia*, *Abraliopsis*, and *Watasenia* have sometimes been removed to another subfamily, the Abraliinae (for example, Voss 1963, 1967), but there is little to justify this on morphological grounds.

The Ancistrocheirinae contains only *Ancistrocheirus*. Another genus, *Thelidioteuthis*, is probably synonymous with it (Nesis 1978). These animals are relatively large and have large bead-like photophores sparsely but regularly distributed over the ventral and lateral surfaces of the mantle and head and on the tentacles. There are no photophores on the eyeballs. The fins are large, with almost straight or slightly convex posterior margins, and the body has a semi-gelatinous consistency.

The Pyroteuthinae, comprising *Pyroteuthis* and *Pterygioteuthis*, are small animals with photophores on the viscera and eyeballs and embedded in the tentacles. There are no photophores on the mantle, head, or arms. There is, however, an abundance of iridophores, which give the animals a silvery, or some-

times golden, appearance. The tip of the mantle is a very thin integumentary layer just covering the sharp-pointed gladius. The fins are each nearly circular in outline.

For generic diagnoses see the key to New Zealand Enoploteuthidae.

Voss (1962) has suggested that when more is known of the detailed anatomy of the various genera of the Enoploteuthidae it may be necessary to create several families instead of one. In spite of the clear distinctions between the subfamilies, the differences are not large enough to justify familial status. The structure of the buccal membrane (shared only with the lycoteuthids), the unique gladius, the biserial armature with a prevalence of hooks, and, most conspicuously, the profusion of photophores are features which unify the family and set it apart from all others.

AREAL AND VERTICAL DISTRIBUTION

Enoploteuthids are, generally, oceanic species, though some (for example, most *Abralia (Stenabralia)* species) may be more coastal (Voss 1963). A few, for example, *Pterygioteuthis giardi*, appear to be almost cosmopolitan (Clarke 1966), but most species (including to some extent the one mentioned) are restricted to water of a certain temperature range. Most are tropical and subtropical, though a few are found in, or even confined to, the temperate zones.

An important faunal boundary for enoploteuthids in the New Zealand region seems to be the Tropical Convergence. During 1976, there were two cruises to the north of the Kermadec Islands, where several species not found on the other, more southerly, cruises were collected. Moderate to large numbers of *Pyroteuthis* n.sp., *Pterygioteuthis microlampas*, and *Enoploteuthis reticulata* were found exclusively north of 28° S, as were single specimens of *Abralia* n.sp. and *Abralia* sp. B; *Pterygioteuthis gemmata* was confined entirely to the south of that latitude. Only *Abraliopsis* n.sp. and *Pterygioteuthis giardi* were found in both areas. Heath (1973) represents the position of the Tropical Convergence, where the waters derived from the East Australian Current meet the Trade Wind Drift, at about 28° S due north of the New Zealand mainland, and so it seems that this boundary between the two current systems accounts for the observed faunal discontinuity. The exact position of the convergence varies throughout the year; it reaches its southerly limit of 30° S in January-March (Ridgway and Heath 1975). The sea surface temperature at 28° S was 21.4–21.8 °C in December 1976 and 19.5–20.5 °C in June 1976 (FRD unpublished data).

The areal distribution of each New Zealand species will be discussed in more detail later.

It has not been possible with the available material to deduce much about the vertical distribution and migration of the New Zealand enoploteuthids. All collections were made with non-closing nets, and most of them at night. The best review of the vertical distribution of pelagic cephalopods is that of Roper and Young (1975). Their data showed that most enoploteuthid species for which information is available migrate strongly from between 300 and 700 m by day to the upper 100 m or so by night. Some specimens (including a few from the New Zealand collections) have been taken at night from the surface. There is no evidence for non-migratory behaviour, nor any evidence of size stratification: all stages beyond the larval stage appear to migrate together.

PREVIOUS WORK ON THE ENOPLOTEUTHIDAE IN NEW ZEALAND

The literature on the Enoploteuthidae of the New Zealand region is confined to reports of five specimens of four species, and some tentatively identified beaks.

Berry (1914b, 1916) recorded two specimens washed ashore at Sunday (Raoul) Island in the Kermadecs. One of these became the type specimen of *Abralia astrolineata* Berry, 1914. The other, which was in poor condition, was tentatively identified as *Abraliopsis hoylei* (Pfeffer, 1884), a poorly known species, the type of which has been destroyed (Young 1972). It is more likely to have been the *Abraliopsis* n.sp. described here.

Massy (1916) assigned two larval specimens taken off Three Kings Islands by the *Terra Nova* expedition to *Pterygioteuthis giardi* Fischer. This species certainly does occur there, but so does *P. gemmata*, which is commoner. The small size of the specimens in question (mantle lengths of 3.0 and 4.5 mm) prevents them from being positively identified as either of these two very similar species.

Dell (1959) described *Enoploteuthis neozelanica* from a single adult male trawled "off Kahu Rocks, east coast of Wellington . . . in 50 fathoms." From the description, this specimen is obviously an *Abraliopsis*, and the suggestion has been made (Clarke 1966, Roper 1966) that it may be conspecific with *A. gilchristi* (Robson, 1924), a view which I believe is correct (see p. 43).

Imber (1973) recorded the beaks of two unidentified species of enoploteuthid from the stomachs of grey-faced petrels (*Pterodroma macroptera gouldi*), and later (1976) noted *Abralia ?astrolineata*, *Abraliopsis ?gilchristi*, *?Pyroteuthis* sp., and *Ancistrocheirus lesueuri* from black petrels (*Procellaria parkinsoni*), *Enoploteuthis? galaxias* and *Abralia* sp. A from Westland black petrels (*P. westlandica*), and *Abralia* sp. A and *A. lesueuri* from white-chinned petrels (*P. aequinoctialis*). Further collections have revealed that the "*Abralia*" beaks are in fact from species of *Onychoteuthis*, and beaks from black petrel stomachs assigned to *Lycoteuthis diadema* by Imber (1975) are from *Enoploteuthis galaxias* (Imber pers. comm.).

MATERIALS AND METHODS

Most of the specimens examined were collected by FRD between 1975 and 1980, during midwater trawling surveys around the New Zealand region. The net used was a fine-meshed midwater trawl with two 2.5-m Suberkrub doors, 55-m sweeps, and an overall netting length of 39 m. The mesh size was graded from 10 cm in the wings down to 1 cm in the cod-end. When fishing, the mouth area was approximately 100 m (10 × 10 m) (Robertson, Roberts, and Wilson 1978). A few specimens have also come from nighttime surface plankton trawls. The vessel used on these cruises was GRV *James Cook*. Some enoploteuthids were collected on the Auckland University *Tui* cruise of 1962, when a 3-m wide Isaacs-Kidd midwater trawl was used. An attempt was made to fish for enoploteuthids with a small Isaacs-Kidd midwater trawl (1.8 × 2-m aperture) from the research vessel *Ikatere* in June 1980 and July 1981, but although several cephalopods were collected, only one was an enoploteuthid. Trawling with this net was carried out on 3 nights east of Great Barrier Island and the Coromandel Peninsula.

The collections examined comprise 1824 specimens representing 14 species. The details of each sample in which enoploteuthids have been recorded are given in Appendix 1. On some of the earlier cruises, some enoploteuthids and other non-commercial squids were caught but discarded without being recorded, though this practice has now ceased (R. H. Mattlin pers. comm.). It is therefore not possible to say with certainty that enoploteuthids are absent from an area just because no specimens have been recorded from there on trawling surveys. For the same reason estimates of relative abundance in different areas, in terms of catch rates per hour, cannot be given.

The sites at which enoploteuthids have been collected are shown in Fig. 1. To some extent this distribution reflects the sampling effort in each area (there have been more cruises on the east coast of the North Island than on the west coast, for instance), but recent cruises along the west coast of the South Island have taken very few enoploteuthids, and none have been taken over the Chatham Rise on the east coast (Robertson, Roberts, and Wilson 1978); so enoploteuthids are probably genuinely rare or absent in these southern regions.

Most sample number codes are of the form Ja/b/c, which follows FRD usage. "J" denotes the vessel used (GRV *James Cook* in all instances), "a" the cruise number, "b" the sample number for that cruise, and "c" the year in which the cruise was undertaken. Samples prefixed "AUZ" were taken on the *Tui* cruise, "JBC" is a specimen from the John Booth collection, "I" denotes the *Ikatere* specimen, and "F" denotes specimens from the National Museum of Victoria, Australia.

Most specimens have been preserved in 5% propylene phenoxytone glycol (PPG), though some are in isopropyl alcohol or 10% formalin.

ABBREVIATIONS, FORMULAS, AND INDICES

Abbreviations used generally follow Voss (1963).

ML	dorsal mantle length: measured from anteriormost point of mantle margin to mantle tip
MW	greatest width of mantle
HL	length of head: measured from anterior point of dorsal nuchal cartilage to junction of dorsal arms
HW	width of head across eyes
FWI	fin width index: greatest width across both fins as a percentage of mantle length
FLI	fin length index: greatest length of fins as a percentage of mantle length

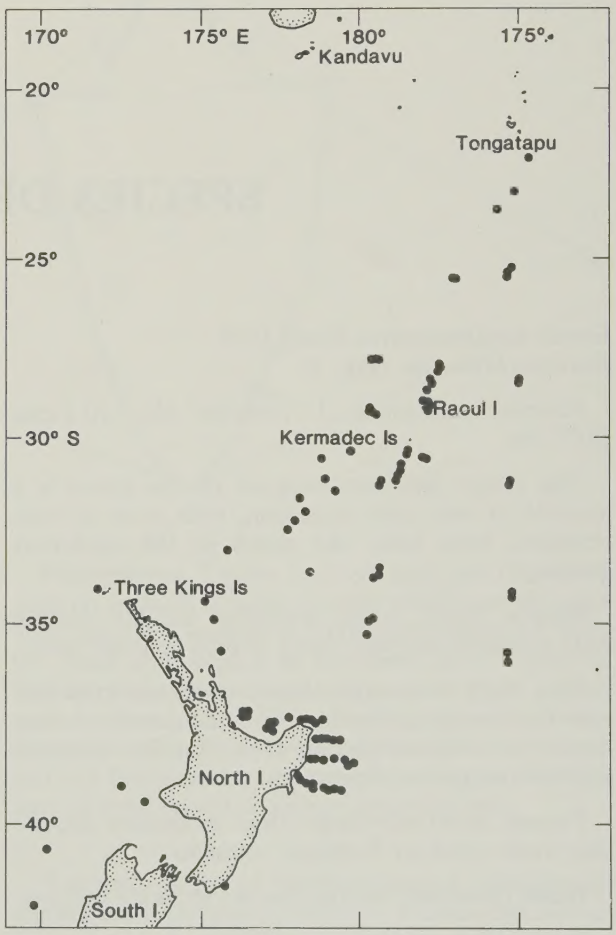


Fig. 1: Sites in the New Zealand region at which enoploteuthids have been collected.

ALI. I	arm length index of dorsal arm: length of arm measured from junction of dorsal arms (also referred to as arms I) to arm tip, as a percentage of mantle length
ALI. II	arm length index of dorsolateral arm: as above, but length of arm measured from junction of arms II and III
ALI. III	arm length index of ventrolateral arm: as above
ALI. IV	arm length index of ventral arm: as above, but length of arm measured from junction of ventral arms (arms IV)
l.	left
r.	right
TLI	tentacle length index: length of tentacle as a percentage of mantle length
CL	club length: measured from proximal carpal sucker to tip of dactylus
FuL	funnel length
AC. I–IV	arm count of arm I–IV: number of hooks on that arm
TC	number of hooks on tentacular clubs
Tail LI	tail length index: length of tail measured from posterior tip of tail to posterior end of fins as a percentage of total mantle length
Arm formula:	Comparative lengths of arms expressed numerically, in decreasing order, as 3. 4. 2. 1 or 4. 3 = 2. 1
Buccal membrane formula:	Position of attachment of buccal connectives to arms I–IV, either dorsally (D) or ventrally (V), as DDVD or DDDD.

For all of the above measurements, and throughout the following descriptions, the orientation of the animals follows teuthological convention, with the arms considered to be placed anteriorly, the fins posteriorly, and the funnel ventrally.

SPECIES DESCRIPTIONS

Genus *Ancistrocheirus* Gray, 1840
***Ancistrocheirus* sp.** (Fig. 2)

Material examined: 1 juvenile ML 20.2 mm J8/77/80.

The single specimen assigned to this genus is a juvenile in very poor condition, with most of both tentacles, both eyes, and much of the epidermis missing.

Mantle. Short, broad, somewhat sac-like. Mantle edge produced dorsally into a bluntly rounded point.

Fins. Very broad, with almost straight anterior and posterior margins. Almost as long as mantle. A very small, free anterior lobe on each. Junction at dorsal midline marked by distinct groove.

Funnel. Relatively large. Held in shallow depression under head by V-shaped retractor.

Head. Distorted, bearing few recognisable features.

Arms. All square in cross section at their bases and becoming rounded distally. Little remaining trace of membranes. Relative lengths uncertain because of damage, but all quite long. Hooks present in two rows along most of their lengths. Several suckers present distally on each, on more intact specimens (Nesis 1978).

Buccal membrane. Typically enoploteuthid.

Photophores. Relatively large, superficial and bead-like, some obviously missing. One of presumed pair adjacent to mantle edge near ventral midline. Another pair wider apart more posteriorly, and posterior to them a pair close together. Most posteriorly two organs about as far apart as the second pair. Two organs close to mantle edge on left side, one on right. Two dorsolaterally on each side.

On head, a pair ventrolaterally, anterior to tip of funnel. A pair anterior to these directly ventral to eyes. A smaller organ on ventral eyelid between these two groups. Three posterior to eye arranged at corners of a broad isosceles triangle. One at anterior dorsal corner of eyelid. A pair at base of tentacles. A series of five organs of uneven size on fragment of left tentacle.

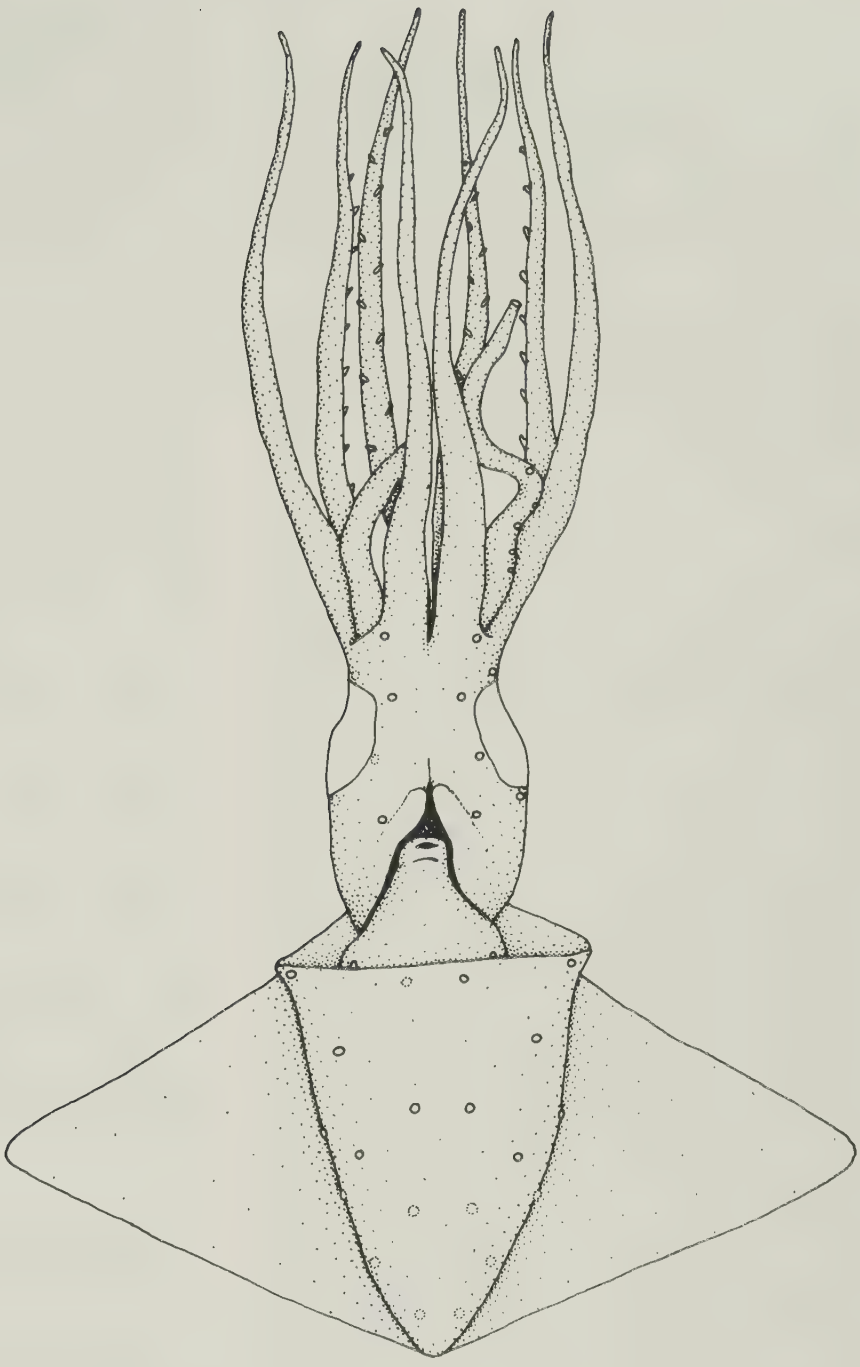


Fig. 2: *Ancistrocheirus* sp., ML 21.2 mm. Considerably reconstructed from single mutilated specimen. Dotted circles show presumed location of missing photophores.

Because this specimen is incomplete, the following notes, based on Sasaki (1929), Okutani (1976), and Nesis (1978), have been added to facilitate identification.

Large specimens (ML 80+ mm) with a caudal extension and consequently subterminal fins.

Arm length formula 2 = 3. 1. 4 in juveniles, 3. 2 = 4. 1 in adults. Ventral arms with lateral webbing, other arms keeled only in adults.

Tentacle. Two rows of seven or eight hooks on manus, ventral hooks larger than dorsal, four or five suckers in carpal cluster, four rows of minute suckers on dactylus.

Photophores. Twelve to 29 photophores of varying sizes on tentacular stalk, number tending to decrease with growth. Twenty-two large photophores on mantle. Head photophores as described above. None on eyeball. Zones of minute organs visible on freshly captured specimens. Three transverse bands on ventral surface of mantle, two longitudinal bands on ventral and lateral arms, two elongate zones on posterior part of head to either side of ventral arms.

Texture. Body of semi-gelatinous consistency: animal has high concentration of ammonium ions in body tissues to render it neutrally buoyant (Clarke, Denton, and Gilpin-Brown 1979).

Distribution

Mature specimens of *Ancistrocheirus* (all assigned to *A. lesueuri*) have been recorded only rarely. They are known from the Azores (Joubin 1900), Felidu Atoll in the Indian Ocean (Hoyle 1906), Japan (Okutani 1976), and Namibia (Okutani and Hasegawa 1979). Beaks have been found almost worldwide in sperm whale stomachs (Clarke 1977), including some from the Tasman Sea, and Imber (1976) records beaks from the stomachs of white-chinned and Westland black petrels in the New Zealand region. Juveniles (*Thelidioteuthis*) have also been taken widely in tropical and temperate seas (Clarke 1966). The single New Zealand specimen was taken east of Poverty Bay (see Fig. 9) at 38° 32.57′ S, 179° 37.24′ E by a net trawled at a depth of 100 m.

Remarks

The systematics of the Ancistrocheirinae are not at all well established. Two species, *Ancistrocheirus lesueuri* (Orbigny, 1839) and *Thelidioteuthis alessandrinii* (Verany, 1851), have been recognised, though it has been widely suspected that the latter is merely the juvenile of the former (Hoyle 1906, Clarke 1966, Roper, Young, and Voss 1969, Okutani 1976). The problem has been a lack of specimens: until recently no ancistrocheirids between 29 and 200 mm ML had been collected (Okutani 1976). Nesis (1978) has now described a series of specimens with mantle lengths ranging from 28 to 93 mm. These go a long way towards bridging the size gap and probably justify Nesis's action of finally synonymising the two genera.

There is still confusion over the number of species, however. Voss (pers. comm.) believes that there is only one species, and most workers agree with him. Nesis also apparently believes this, but he points out that the whereabouts of the type specimen of *A. lesueuri* is unknown, and that the species was described only sketchily and had an extremely vague type locality ("Le Grand Ocean"—the Pacific?). Furthermore, Orbigny's plate shows a specimen with an uneven row of six photophores down the ventral midline of the mantle and on to the tail (the reproduction of this plate which I have is unclear on this point), whereas all specimens taken subsequently have no such line and no organs on the tail. The type also appears to be more slender than either Hoyle's or Okutani's specimen (Okutani 1976). It is possible that the specimen was inaccurately illustrated, or the photophores may have been displaced through damage. The number of mantle photophores (22) is the same as on subsequent specimens. The alternative to the above is that *A. lesueuri* has not been recorded since it was described and all subsequent specimens belong to a second species, *A. alessandrinii*.

The present specimen does nothing to clarify the situation. The photophores that have not been lost appear to have a typical ("*alessandrinii*"-type) arrangement. The only other character worth mentioning is the large size of the fins. Juveniles with mantle lengths of 20–30 mm usually have fin width indices of 110–136 (Sasaki 1929, Nesis 1978). This specimen has an index of 175. (It is possible that the mantle has contracted somewhat in the preservative, but the fin width index could still not be less than 150.) The New Zealand population may therefore eventually prove to be a new species, though with only one specimen available (and that a juvenile) nothing more can be said at present.

Genus *Pyroteuthis* Hoyle, 1904

Pyroteuthis serrata n.sp. (Fig. 3)

Material examined: 1 male ML 27.3 mm J17/32/76 (holotype); 4 females ML 40.3 mm, 34.7 mm, 28.0 mm, 22.7 mm J17/47/76 (paratypes); 4 males ML 29.7 mm, 21.1 mm, 19.8 mm, 12.7 mm J17/71/76; 2 males ML 28.3 mm, 26.8 mm J17/67/76; 2 males ML 27.1 mm, 26.5 mm J17/64/76; 1 male ML 19.5 mm J17/47/76; 1 male ML 17.3 mm J9/47/76; 1 male ML 16.8 mm J17/60/76; 1 female ML 28.3 mm J9/47/76; 1 female ML 44.9 mm J9/41/76; 2 juveniles ML 16.1 mm, 9.0 mm J17/58/76; 2 females ML 16.1 mm, 13.5 mm J17/60/76; 1 juvenile ML 10.0 mm J17/60/76; 2 juveniles ML 12.9 mm, 11.5 mm J17/47/76.

Detailed measurements of some specimens are given in Table 1.

Mantle. Broad, conical, distinctly convex in outline dorsally, concave ventrally. Gladius tip a very sharp point covered by a very thin layer of integument: posterior tip of mantle, therefore, very sharp pointed. Mantle margin produced dorsally into a broad V, a small projection at each locking cartilage.

Fins. Subterminal, membranous, nearly circular, length 35–40% that of mantle. Not quite meeting at dorsal midline, which is marked by dark vane of gladius.

Funnel. Slender, but quite long, with V-shaped retractor dorsally, sitting in deep groove in ventral surface of head.

Head. Large, broader than mantle, with very large eyes, often protruding from sockets in preserved specimens. Eye socket without anterior sinus. Olfactory papilla to either side of funnel groove, no nuchal crests.

Arms. Moderate size, subequal, order of length 4. 3. 2. 1. Squarish in cross section at bases, more circular distally, tapering finely. Ventral arms with broad lateral membranes, rudimentary protective membranes. Other arms with well developed, trabeculate, ventral protective membranes. A large keel on arm III arising one-third of way along aboral surface, running to tip. Arms I and II with rudimentary keels, confined to tips. Ventral arms with 21–28 hooks, replaced distally by about 20 (13–29) minute, widely spaced suckers. Hooks of other arms larger, numbering 12–17 on arms I, 11–15 on arms II, and 14–18

on arms III. Suckers proximally and distally on arms I–III; proximal suckers large, dark, distal suckers few, minute. Armature of both sexes similar.

Hectocotylus. On right ventral arm of male. Twelve hooks in two rows proximally: each hook with large, sharply pointed secondary cusp, primary cusp with irregularly serrated inner edge (Fig. 4). An elongate fleshy membrane on ventral edge distad of these. Eight to eleven small hooks in two irregular rows opposite membrane. Three pairs of small hooks distally, then a long section bearing 10–19 minute suckers.

Tentacles. Long and slender, with a distinct bend at base of each (Fig. 4). Clubs not expanded. Three sessile, untoothed suckers in carpal cluster. On manus, a row of four or five minute suckers ventrally, four or five broad-based hooks medially, seven or eight larger suckers dorsally in one row. Dactylus very long, with four rows of small suckers, becoming minute distally. No keels or membranes aborally.

Photophores. Six on tentacle. Most proximal small, silvery white, rounded, deeply buried in aboral surface at distal end of basal bend. A similar organ embedded aborally near carpus. Four large oval photophores embedded aborally between these, inconspicuous on preserved specimens, but occasionally showing as slight swellings, perhaps rather darker than rest of tentacle, evenly spaced, grouped towards centre of stalk.

Twelve iridescent photophores on eyeball: a longitudinal row of three very large organs anteriorly, more laterally and posteriorly three smaller organs, then a larger organ having a row of three minute organs anteriorly and medially of it, a moderately sized organ just posteriorly. One large organ just posterior to lens.

On viscera, a large photophore to either side of rectum, three small organs in a transverse row between gills, median organ largest. Ventral to efferent branchial artery on each side an organ about the size of median photophore. Posteriorly a median series of three organs; anterior two sometimes bilobed, overlying gonad, the third in gladius tip, visible from exterior.

Buccal membrane. Large, dark. Modified to form web joining basal halves of two dorsal pairs of arms. Connectives attached DDVD, eight lappets, though arrangement somewhat obscured by development of webbing.

Colour. Mantle, head, and arms silvery (due to iridophores). Chromatophores reddish brown, particularly dense on dorsal surfaces and bases of ventral arms.

Spermatophores. Length 6.3–6.4 mm, sperm mass not reaching to aboral tip. Cement body well defined but simple. Spiral filament thick, with well marked transverse striations (Fig. 4).

Distribution

This species is recorded for the first time: so far it has been found only in the New Zealand region, north of the Tropical Convergence; south of this it is replaced by the next species, *P. margaritifera* (Fig. 5). It was taken at night in non-closing nets trawled at depths of 73, 94, 327, 377, 397, about 400, and 613 m. These are considerably deeper than most of the nighttime captures of the better known *P. margaritifera*, but the data are far too sketchy to make any positive assertions about the vertical distribution of this species.

TABLE 1: Measurements of *Pyroteuthis serrata*

Sample No.		J9/41/76	J17/71/76	J17/71/76	J17/32/76	J17/47/76
Sex		F	M	M	M	F
ML		44.5	29.7	21.1	27.3	40.3
MW		15.5	8.5	7.8	7.7	13.8
FLI		39.6	37.0	39.3	36.3	39.2
FWI		72.5	65.0	68.7	60.4	75.2
HW		14.8	9.0	6.2	–	–
ALI. I	l.	60.4	41.4	–	46.9	51.6
	r.	58.0	45.5	41.7	47.6	56.8
ALI. II	l.	64.6	43.8	56.4	51.3	59.0
	r.	64.6	48.8	47.4	49.5	61.5
ALI. III	l.	66.3	54.9	64.0	54.9	73.4
	r.	66.4	57.6	61.6	56.8	–
ALI. IV	l.	67.0	46.5	52.1	53.1	64.8
	r.	63.7	–	–	51.3	64.8
TLI	l.	167	–	–	–	173
	r.	–	–	–	–	–
AC. I	l.	17	16	–	–	11
	r.	16	16	15	–	13
AC. II	l.	16	15	14	–	11
	r.	16	15	14	–	14
AC. III	l.	17	17	14	–	14
	r.	16	16	13	14	13
AC. IV	l.	27	32	28	33	18
	r.	28	30	28	30	21

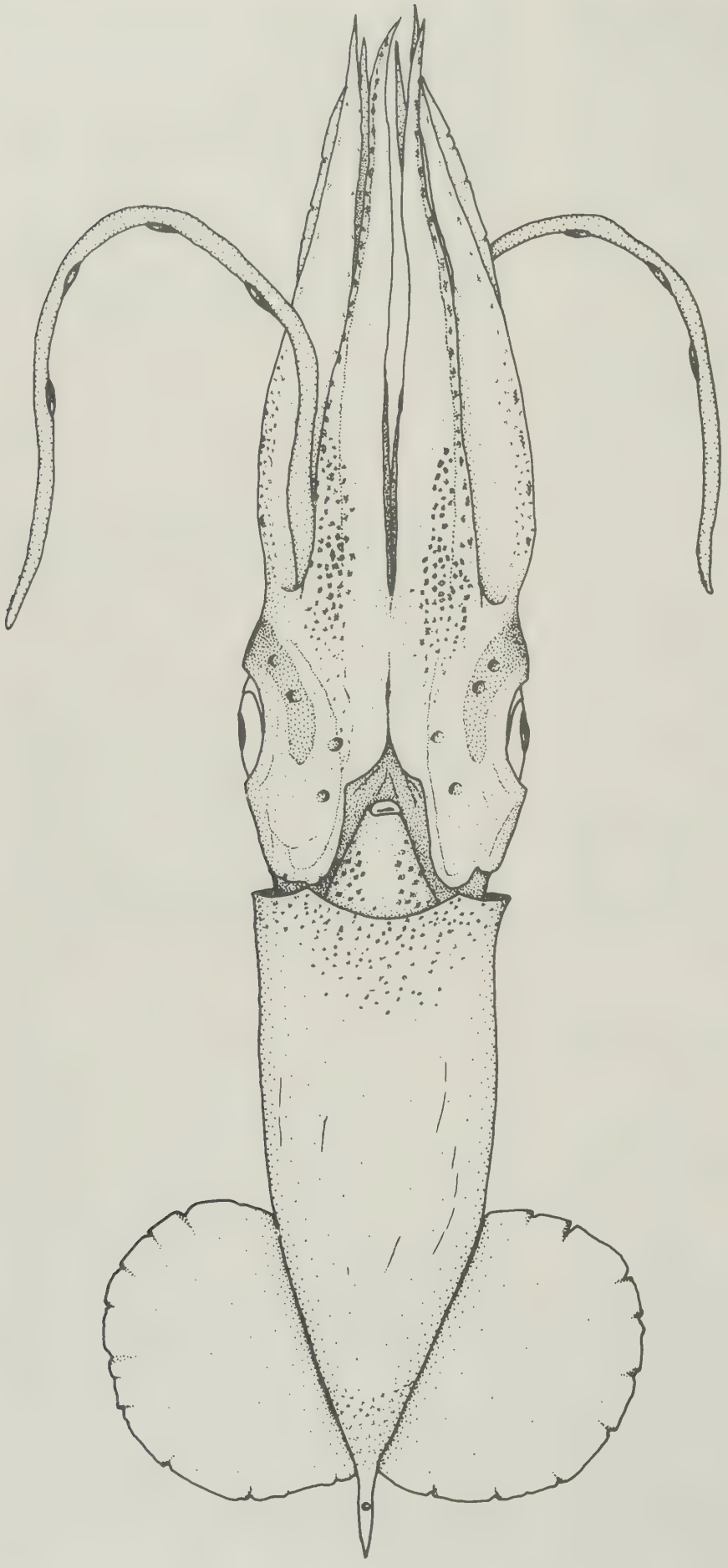


Fig. 3: *Pyroteuthis serrata*, ML 29.7 mm, male.

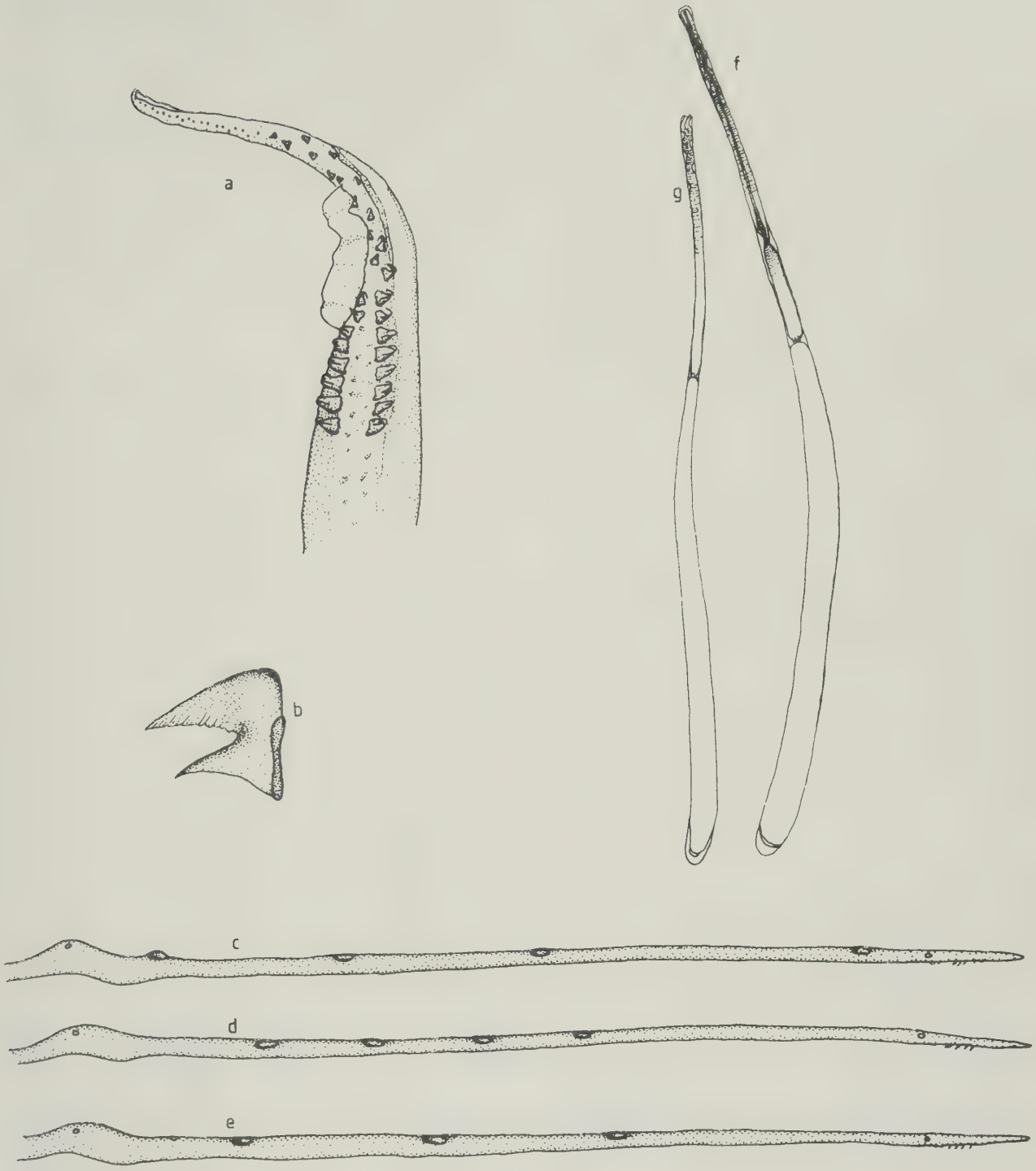


Fig. 4: a, *Pyroteuthis serrata* hectocotylus; b, *P. serrata* second hook proximal to pad on ventral row of hectocotylus; c, *P. addolux* tentacle; d, *P. serrata* tentacle; e, *P. margaritifera* tentacle; f, *P. serrata* spermatophore; g, *P. addolux* spermatophore.

Remarks

This is the third species of *Pyroteuthis* to be described. It differs from the first, *P. margaritifera*, in having four large, oval photophores and two small, spherical photophores embedded in the tentacles, rather than three of each. The distributions of these organs are shown in Figs. 4d and 4e. The hectocotylus is also different: there are 10–12 proximal hooks, rather than 13–19, and these are modified very distinctively. The primary cusp has an irregularly serrated lower edge, and the secondary cusp is as long as the primary and very sharp pointed (Fig. 4b). In *P. margaritifera* the primary cusp is smooth edged and the secondary cusp is large and rounded (Fig. 6b). Distad of these hooks on the ventral edge is an elongated flap in *P. serrata* and a fleshy pad in *P. margaritifera*. Distally there are several minute suckers in *P. serrata* and usually none (occasionally one or two) in *P. margaritifera*.

Other differences are in the small number of suckers on the tips of the ventral arms (0–13 in *P. margaritifera*, 13–29 in *P. serrata*) and in the structure of the spermatophores (Figs. 4f and 6e), although those of *P. margaritifera* seem to be rather variable.

The other species, *P. addolux* Young, is much closer to the present species. To examine properly the relationship between the two, some specimens of *P. addolux* from Hawaii were borrowed from the collections of the Smithsonian Institution. Young (1972) described the tentacles of *P. addolux* as having two small photophores embedded proximally, followed by four evenly spaced elongate photophores and a third small organ near the carpal cluster. The presence of another small organ proximally would clearly distinguish *P. addolux* from the present species, but this organ could not be located in the specimens from Hawaii; apparently it is also occasionally absent in the Californian specimens (Young pers. comm.).

The tentacles of the Hawaiian specimens nonetheless appear different from those of *P. serrata*. The first large photophore is only a short way distad of the proximal small organ and is distinctly rounder and more protuberant than the other large organs. The fourth large organ is found a short distance proximally of the carpal cluster. In *P. serrata* all the large organs have a similar appearance and are grouped more towards the middle of the tentacle (Figs. 4c and 4d).

Again, there are several differences in the hectocotylus. The proximal hooks of *P. addolux* are much smaller, with a smooth-edged primary cusp and a very short secondary cusp (see Young 1972 pl. 4, fig. s). The ventral flap is much shorter, almost semicircular in outline, and has 6 or 7 hooks dorsally, rather than 10–12. Distally, *P. serrata* has a longer sucker-bearing section than does *P. addolux*, though the number of suckers overlaps considerably: 6–15 in *P. addolux*, 7–20 in *P. serrata*.

The number of hooks on the ventral arms of *P. serrata* (27–33) is usually greater than in *P. addolux* (17–25). However, one specimen of *P. serrata* was found to have 18–21 ventral arm hooks, and so this

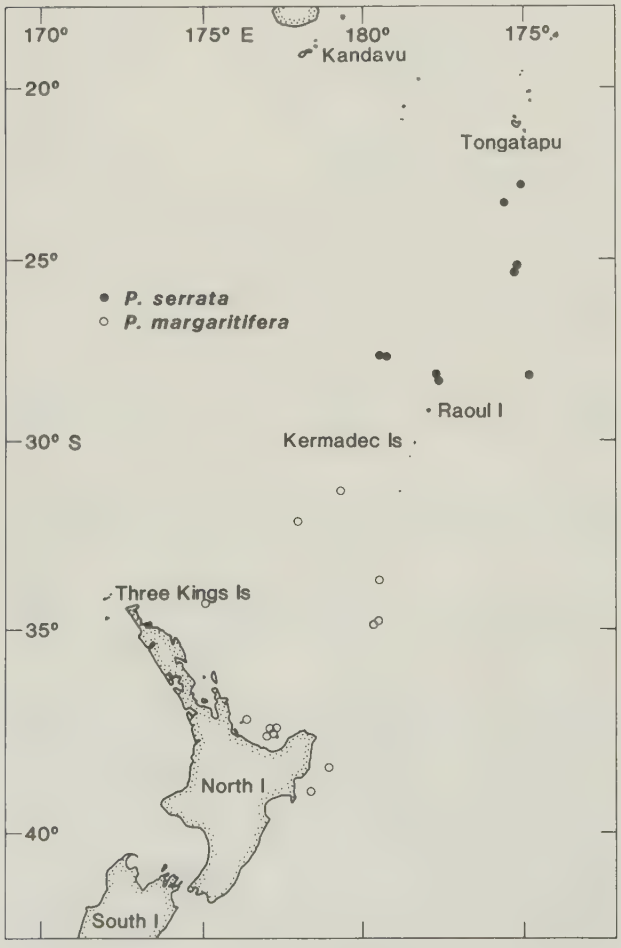


Fig. 5: Distribution of *Pyroteuthis* spp.

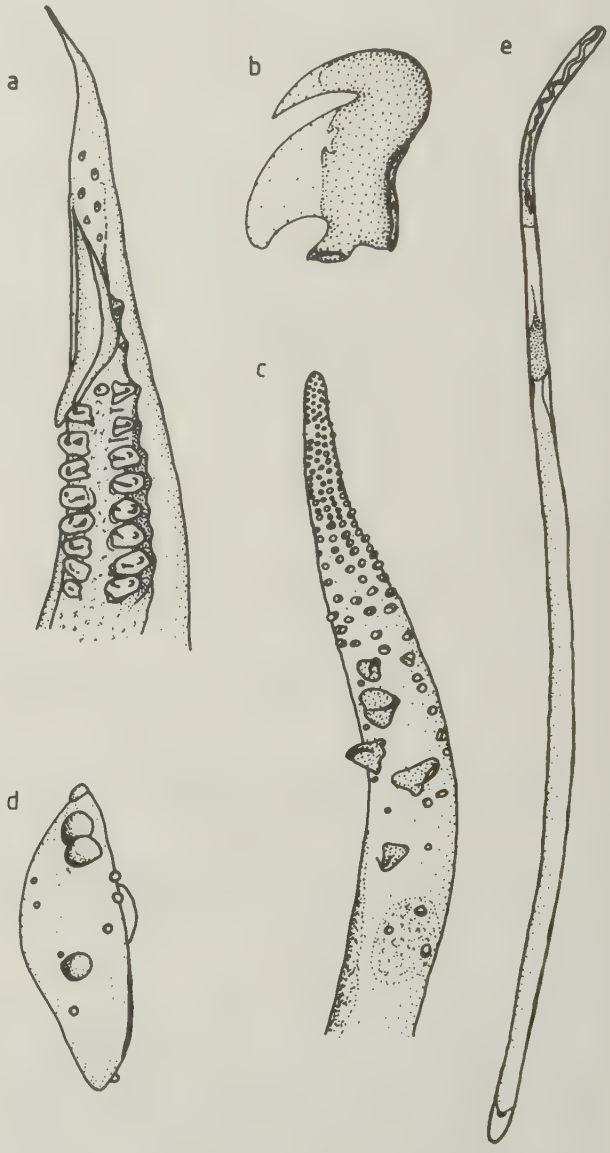


Fig. 6: *Pyroteuthis margaritifera*: a, hectocotylus; b, second hook proximal to pad on ventral row of hectocotylus; c, right tentacular club; d, photophores of left eye (ventral view); e, spermatophore (length 4.8 mm).

character is not entirely reliable. Young (1972) suspected that the armature of *P. addolux* may exhibit sexual dimorphism, though he had only one male on which to base his description. No sign of sexual dimorphism, however, could be found in the *P. addolux* specimens examined here.

The spermatophores of *P. serrata* are distinctly larger than those of *P. addolux* (6.3 versus 5.6 mm) and have a much more clearly defined cement gland. The two mature male *P. addolux* examined had spermatophores like those of Young's specimen.

Pyroteuthis margaritifera (Ruppell, 1844)

Enoploteuthis margaritifera Ruppell, 1844 p. 2, fig. 1; Verany, 1851 p. 82, pl. xxx, fig. a; Claus, 1858 p. 262, fig. 2; Tryon, 1879 p. 172; Hoyle 1886 pp. 171–2, pl. xxix, fig. 11.
Pterygioteuthis margaritifera Pfeffer, 1900.
Charybditeuthis margaritifera Pfeffer, 1900.
Pyroteuthis margaritifera Hoyle, 1904.
Pyroteuthis juv. Issel, 1908.
Benthoteuthis megalops Pfeffer, 1912.

Material examined: 1 male ML 18.6 mm AUZ 002 08; 1 juvenile ML 13.7 mm AUZ 008 11; 1 male ML 13.0 mm AUZ 091 02; 7 females ML 11.3–15.2 mm J7/56/75; 3 males ML 12.2–15.6 mm J7/56/75; 3 females ML 11.8–19.5 mm J12/39/75; 1 head J12/39/75; 1 juvenile ML 15.0 mm J12/39/75; 1 male ML 16.3 mm J12/41/75; 2 females ML 16.0 mm, 18.9 mm J12/56/75; 4 females ML 23.0–26.4 mm J17/39/75; 5 males ML 20.0–26.8 mm J17/39/75; 5 females ML 23.7–29.0 mm J17/42/75; 1 male ML 27.1 mm J17/42/75; 5 females ML 17.2–21.4 mm J17/54/75; 6 males ML 15.0–19.2 mm J17/54/75; 1 male ML 23.4 mm J17/60/75; 2 females ML 17.5 mm, 18.5 mm J11/87/76; 2 females ML 16.0 mm, 18.2 mm J11/99/76; 1 male ML 19.2 mm J17/6/76; 1 female ML 17.0 mm J17/7/76; 1 female ML 11.9 mm J17/9/76; 1 male ML 15.0 mm J17/22/76; 1 juvenile ML 12.8 mm J17/60/79; 1 male ML 20.6 mm J1/6/80; 1 female ML 18.2 mm J1/14/80; 1 female ML 35.9 mm J1/50/80; 2 males ML 32.2 mm, 35.1 mm J1/53/80; 1 female ML 17.7 mm J1/53/80.

Distribution

Most of the records of *P. margaritifera* are from the North Atlantic Ocean and the Mediterranean Sea (Clarke 1966), which probably reflects the distribution of teuthologists as much as anything. The species has also been collected in the south-west Indian Ocean off Natal (Roeleveld, unpublished data), in Indonesia and the central Pacific Ocean (Hoyle 1886, Adam 1954), and the South Pacific Ocean (Young 1972). Hoyle's and Adam's records are, perhaps, questionable, particularly Hoyle's for the central Pacific; there are two other similar species, undescribed at the time, but now known from this general region, with which *P. margaritifera* could easily be confused. Adam's specimen was a juvenile in poor condition. In the New Zealand region the species is known to occur from off Poverty Bay northwards to 32° S (Fig. 5). It will probably eventually be found to have a distribution similar to that of *Pterygioteuthis gemmata.*

Clarke and Lu (1974) studied the vertical distribution of this species in the North Atlantic. They found it to be apparently confined to the upper 200 m at night and to disperse throughout the water column to 640 m by day. All but one of the day captures was below 100 m. Off Bermuda, the species migrates from 75–175 m at night to 375–500 m during the day (Roper and Young 1975). Roper (1973) collected the species between 50 and 250 m at night and at 400–600 m by day in the Mediterranean. As well as this vertical migration, Roper suggests that there is a seasonal migration eastwards in winter, away from the Tyrrhenian Sea, which is the summer centre of abundance.

Remarks

This species is very similar in appearance to *Pyroteuthis serrata*: characters for distinguishing the two are discussed in the previous section.

Although it is not possible to distinguish the present species from *P. margaritifera* as described in the literature, it appears to differ from *P. margaritifera* from the Atlantic in that on the tentacles it has two small photophores followed by three large ones, whereas Atlantic *P. margaritifera* has one small organ followed by four large ones (Young pers. comm.). Direct comparisons of specimens from the Atlantic and Pacific will be required to establish the true identity of the local species.

Genus *Pterygioteuthis* Fischer, 1869

Pterygioteuthis giardi Fischer, 1896 (Fig. 7)

Pyroteuthis (Pterygioteuthis) giardi Pfeffer, 1912 pp. 193, 204, 774.
Pterygioteuthis giardi Fischer, 1896 p. 205.
non *Pterygioteuthis giardi* Berry, 1909 p. 419.

Material examined: 11 specimens ML 11.5–18.4 mm J17/68/76; 10, ML 12.8–17.6 mm J17/65/76; 5, ML 13.0–18.0 mm J9/56/76; 3, ML 12.9–15.4 mm J17/58/76; 3, ML 11.5–13.0 mm J9/68/76; 2, ML 16.5 mm, 16.5 mm J17/60/76; 2, ML 13.0 mm, 17.8 mm J17/67/76; 2, ML 17.1 mm, 17.2 mm J9/45/76; 2, ML 13.1 mm, 13.6 mm J9/15/76; 2, ML 11.3 mm, 13.7 mm AUZ 091 02; 2, ML 14.4 mm, 16.5 mm J17/30/76; 1, ML 16.8 mm J17/6/76; 1, ML 15.5 mm J17/10/76; 1, ML 15.5 mm J9/58/76; 1, ML 15.2 mm AUZ 045 05; 1, ML 14.7 mm J9/67/76; 1, ML 14.1 mm AUZ 002 08; 1, ML 13.3 mm J9/43/76.

This species and the two following are all very similar. Since a full description of the next species, *P. gemmata*, has recently been presented by Young (1972), this section and the one following are largely concerned with identifying characters only, and full descriptions are not given. The third species, *P.*

microlampas, has not been well delineated in the past and so it will be discussed at some length.

Mantle. Roughly cylindrical anteriorly, flared at margin, tapering to sharply pointed tip posteriorly. Gladius tip covered by very thin layer of epidermis.

Fins. Nearly circular, delicate, about one-third of mantle length in diameter.

Head. Moderate size, with very large eyes forming prominent swellings laterally, often protruding from sockets.

Arms. Short and slender, order of length 3. 4. 2. 1. Dorsal arms with four to six pairs of suckers proximally, four to six pairs of hooks in their mid portions, two rows of numerous minute suckers distally. Lateral arms with four to five pairs of suckers proximally, followed by two to four hooks, occurring in both rows. Distal suckers absent. Ventral arms lacking armature.

Hectocotylus. Occurring on left arm of male. Proximally a dark, sausage-like swelling running along oral surface of arm. Two lobes at distal end of this, forming two sides of small pocket containing a small, bidentate plate. A low keel aborally, hooks and suckers absent (Fig. 8a).

Tentacles. Very slender. Clubs with four rows of small suckers, largest proximally, each row about 20 suckers long (Fig. 8c). Manus and dactylus not clearly differentiated. Two sessile suckers in carpal cluster.

Photophores. Absent from mantle, head, and arms. Epidermis instead well endowed with iridophores, giving animal a silvery or golden appearance. The iridophores of *P. microlampas* are discussed in detail by Young (1977). Four small white photophores embedded in each tentacle, one near base, one near carpus, two in mid portion: all often difficult to find. Fifteen large iridescent organs on eyeball arranged as in Fig. 8d. One organ to either side of rectum, one between bases of gills, two very large ones overlying (ventral to) branchial hearts, three small organs on ventral midline posteriorly: the last of these lying in gladius tip, almost level with posterior edge of fins.

Chromatophores. Reddish brown. Large, but sparse. Densest anteriorly and dorsally on mantle.

Size. Very small. Females up to 20 mm ML, males 17 mm ML (Clarke 1966).

Spermatophores. Small, simple (Fig. 8f). Spiral filament slightly coiled as it leaves plump sperm mass. Cement gland not apparent.

Distribution

This species has been caught on many occasions all over the world in tropical and warm temperate seas and is, perhaps, one of the most abundant of the pelagic cephalopods. Clarke (1966) has reviewed the literature on *P. giardi*. More recent records are provided by Voss (1971) (tentative), Morales and Guerra (1977), Clarke (1969), Cairns (1976), and Clarke and Lu (1974). In the New Zealand region it is fairly

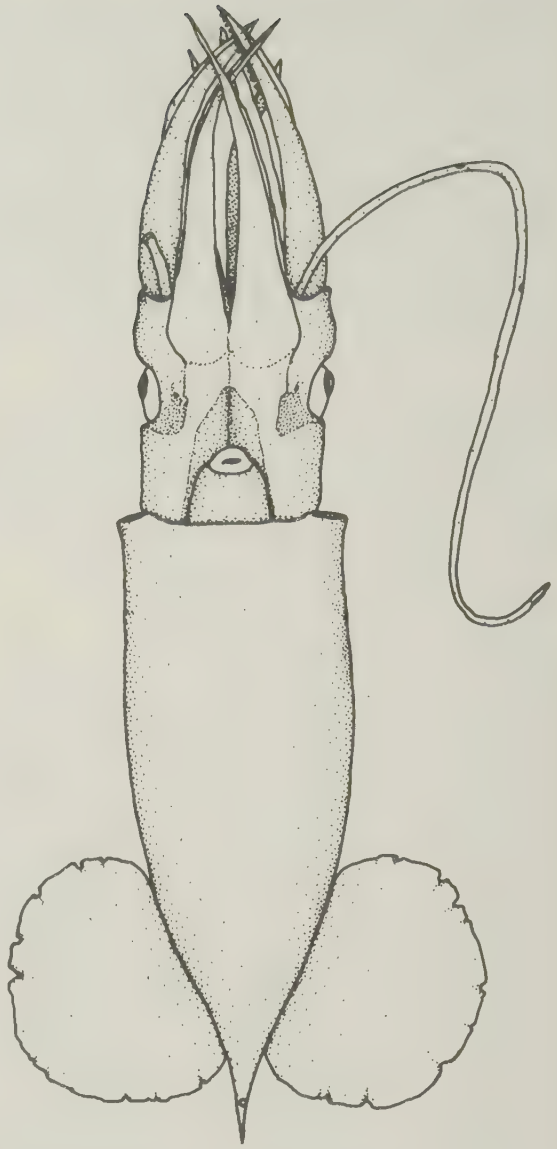


Fig. 7: *Pterygioteuthis giardi*, ML 18.2 mm, female.

common north of about 32° S, but rapidly decreases in numbers south of this and has not yet been recorded south of 35° S (Fig. 9). The species has not been caught inshore around the Kermadecs (the only shallow-water area within its range that was trawled). It appears to be strictly oceanic, as is its close relative *P. gemmata*.

By night this species lives in the upper 200 m, with the greatest concentration at about 50–60 m. At dawn, animals migrate down to 300–500 m (Roper and Young 1975, Clarke 1969, Clarke and Lu 1974), though a few may remain as shallow as 50 m (Clarke 1969). Juveniles less than 4 mm do not show marked migrations and are found between 100 and 200 m by day (Clarke and Lu 1974).

Remarks

Distinguishing characters will be discussed in the section on *P. gemmata*.

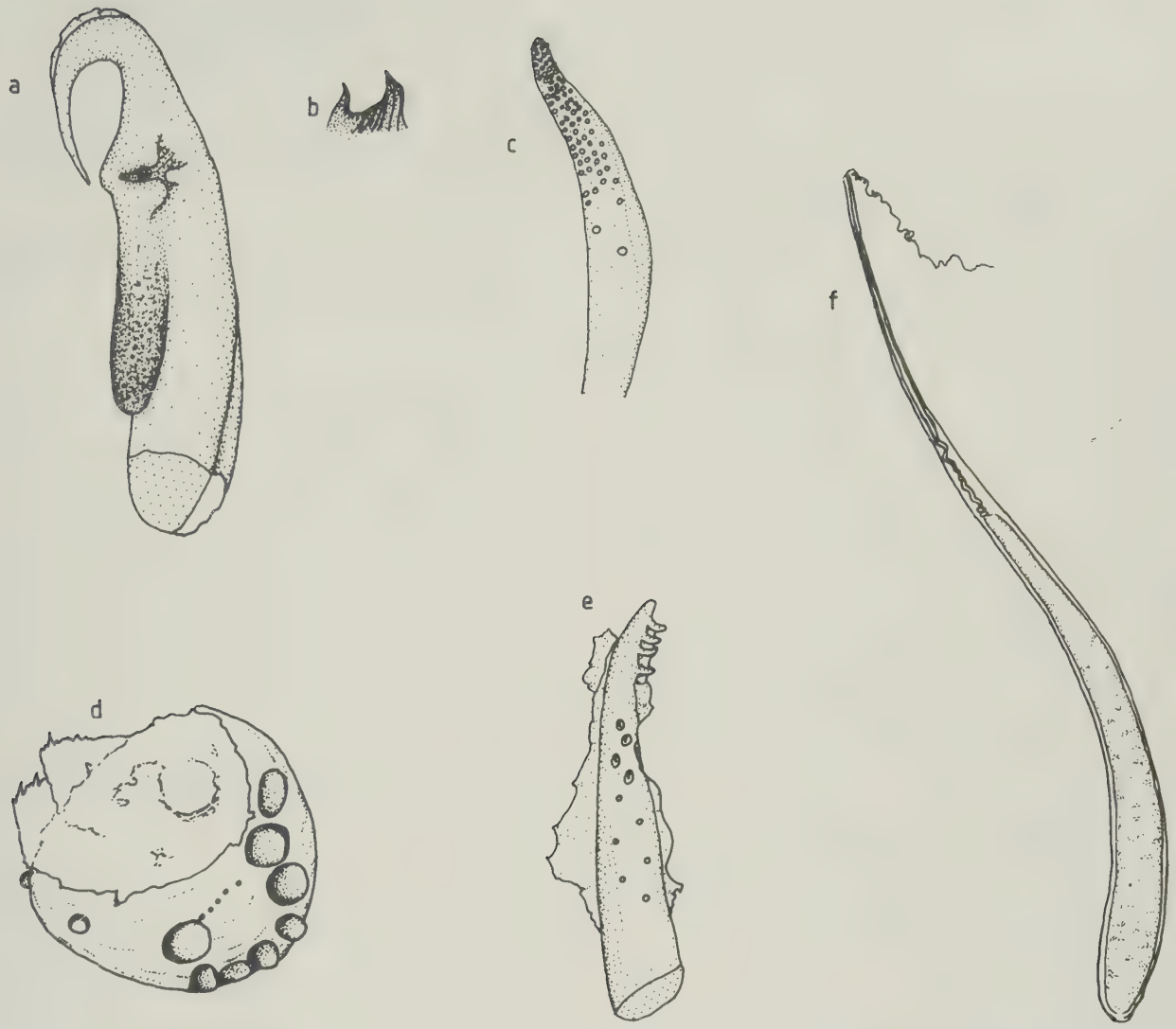


Fig. 8: *Pterygioteuthis giardi*: a, hectocotylus; b, plate from hectocotylus pocket; c, left tentacular club; d, photophores of left eyeball (ventral view, eyeball removed from animal); e, left arm II; f, spermatophore.

***Pterygioteuthis gemmata* Chun, 1908** (Fig. 10)

Pterygioteuthis gemmata Chun, 1908; 1910 p. 108, pl. 13, fig. 3; pl. 14, figs. 4, 5, 9; pl. 15, figs. 2, 3, 6–12; pl. 16, figs. 1, 2, 5, 7–19; Pfeffer, 1912 p. 194; Thiele, 1921.

Material examined: 6 males ML 22.3–24.5 mm J17/10/76; 5 females ML 26.8–31.0 mm J17/10/76; 2 females ML 29.1 mm, 30.5 mm J17/77/76; 1 male ML 23.4 mm J17/21/76; 1 male ML 22.7 mm J17/12/76; 2 females ML 24.0 mm, 25.5 mm J17/12/76; 1 male ML 19.9 mm J17/32/76; 1 female ML 24.2 mm J17/79/76; 1 male ML 23.2 mm J17/7/76; 1 female ML 30.6 mm J17/7/76; 1 male ML 14.5 mm J9/34/76; 1 male ML 21.2 mm J9/56/76; 1 male ML 21.3 mm J9/12/76; 1 female ML 13.2 mm JBC; 4 males ML 17.0–18.5 mm J18/33/78; 3 females ML 15.7–26.0 mm J18/33/78; 2 males ML 18.3 mm, 20.7 mm J13/20/79; 1 male ML 20.8 mm J13/4/79; 1 male ML 19.6 mm J15/4/79; 1 male ML 21.9 mm J15/39/79; 1 male ML 17.8 mm J16/5/79; 5 females ML 16.5–21.7 mm J16/5/79; 1 male ML 22.5 mm J1/4/80; 1 male ML 21.3 mm J1/17/80; 2 males ML 23.4–25.3 mm J1/37/80; 1 female ML 25.8 mm J1/37/80; 1 female ML 25.0 mm J1/36/80; 1 male ML 20.0 mm J1/51/80; 1 male ML 23.3 mm J1/3/80; 3 females ML 26.0–30.3 mm J1/6/80; 1 female ML 29.5 mm J1/53/80; 1 female ML 20.2 mm AUZ 067 18; 1 male ML 22.5 mm AUZ 002 08; 2 males ML 15.2 mm, 18.5 mm AUZ 091 02; 1 female ML 19.3 mm AUZ 091 02; 1 male ML 17.5 mm AUZ 115 06; 1 male ML 14.8 mm AUZ 121 01; 1 male ML 21.2 mm J16/73/76; 1 female ML 16.5 mm AUZ 097 05; 3 males ML 15.4–20.5 mm AUZ 086 02; 1 unsexed ML 19.0 mm AUZ 080 04; 1 female ML 18.8 mm J12/41/75; 1 unsexed ML 15.2 mm J12/41/75; 1 male ML 14.9 mm J12/37/75; 2 females ML 14.5 mm, 15.6 mm AUZ 068 03; 1 male ML 20.0 mm J17/42/75; 1 female ML 22.7 mm J17/42/75; 1 female head only I10/81.

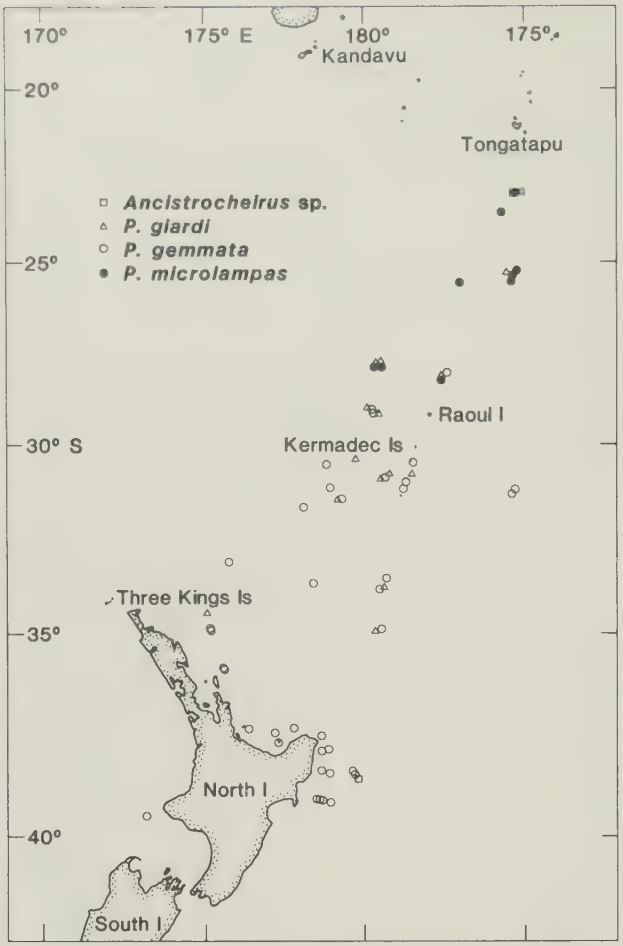


Fig. 9: Distribution of *Ancistrocheirus* sp. and *Pterygioteuthis* spp.

This species is similar to *P. giardi*, but there are the following differences.

The dorsal and lateral arms have three to five hooks along the mid portions of the ventral rows only. Arms III usually have more hooks than the other arms. There are suckers distally on all arms, including the ventral pair, though here they are minute. The proximal suckers of the ventral arms are partially hidden by membranes and are tiny and easily lost; so they may be difficult to find at all.

The hectocotylus has a fleshy ridge proximally and distally, with a pocket between these ridges. This pocket has pleated sides and contains a plate with about 10 teeth on it (Fig. 11a, 11b). A few suckers may be found distally, but these are easily lost.

There are only 14 photophores on the eyeball: one of the minute organs on the inner ventral surface is absent (Fig. 11e). These organs are easily damaged or displaced and may appear rather different from that in the figure.

The animal grows to be much larger than *P. giardi*: females reach at least 32 mm ML; males may be 28 mm (Young 1972). New Zealand specimens are known to reach 31 and 25.3 mm respectively.

In well preserved animals a few differences in body proportions can be noted. The mantle is often not as slender as in *P. giardi*, the head tends to be rather squarer, and the chromatophores are perhaps more prominent. With experience, it is often possible to distinguish the two species at a glance, but the other characters should always be checked for positive identification.

The spermatophores are much more slender. The spiral filament coils not more than once as it leaves the sperm mass (Fig. 11g).

Distribution

Since *P. gemmata* was first recorded by Chun (1908) from the South Atlantic, specimens identified as this species have been collected in all oceans (Voss 1967, Young 1972, Clarke and Lu 1974, Cairns 1976, Lu and Roper 1979). It has been captured less often than *P. giardi*. In New Zealand waters *P. gemmata* extends as far north as the Tropical Convergence, where it is replaced by *P. microlampas*. None has been found over the continental shelf, but otherwise the species occurs widely around the Kermadecs and along the east coast of the North Island. There is one record off Taranaki on the west coast (Fig. 9).

By day, *P. gemmata* occurs primarily between 300 and 800 m depth, but migrates to the upper 200 m by night (Roper and Young 1975).

Remarks

This species will be considered further in the discussion on *P. microlampas*.

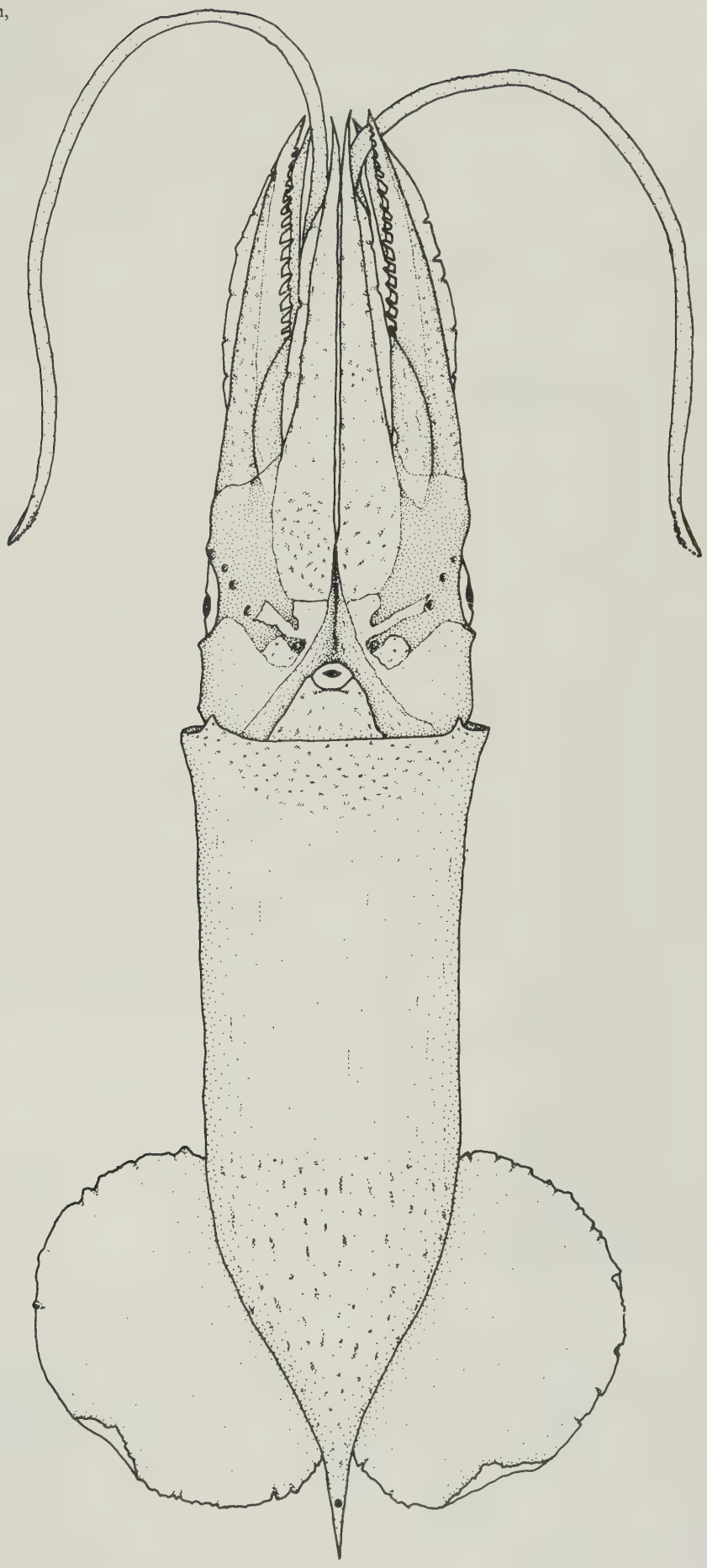
Pterygioteuthis microlampas Berry, 1913

Pterygioteuthis giardi Berry, 1909 p. 419.
Pterygioteuthis microlampas Berry, 1913 p. 566; 1914 pp. 332–4, figs. 35, 36; Arnold and Young, 1977 pp. 161–90; Young *et al.*, 1979 pp. 69–78.

Material examined: 23 males ML 13.0–19.8 mm J17/58/76; 15 females ML 13.2–22.5 mm J17/58/76; 81 unsexed ML 8.8–18.9 mm J17/58/76; 3 males ML 15.8–19.2 mm J17/65/76; 7 females ML 14.2–21.0 mm J17/65/76; 61 unsexed ML 10.0–18.2 mm J17/65/76; 23 males ML 13.1–19.6 mm J17/30/76; 12 females ML 14.9–22.5 mm J17/30/76; 3 males ML 13.2–16.2 mm J17/60/76; 2 females ML 17.0 mm, 16.2 mm J17/60/76; 1 male ML 18.8 mm J17/39/76; 2 females ML 21.4 mm, 22.6 mm J17/39/76; 1 male ML 19.6 mm J17/67/76.

This species has had a rather sketchy history. It was first described by Berry (1913, 1914a) from two small female specimens taken off Hawaii, neither of which is apparently extant (Young 1972). Berry used four characters to establish the species, none of which, as Young (1972) points out, is really distinctive. Young was, in 1972, clearly of the opinion that this species was synonymous with *P. gemmata*, but as the type specimens had been lost, he was reluctant to synonymise the species before examining more specimens from Hawaii. Since then, he has had the opportunity

Fig. 10: *Pterygioteuthis gemmata*, ML 31.0 mm, female.



Inset 4

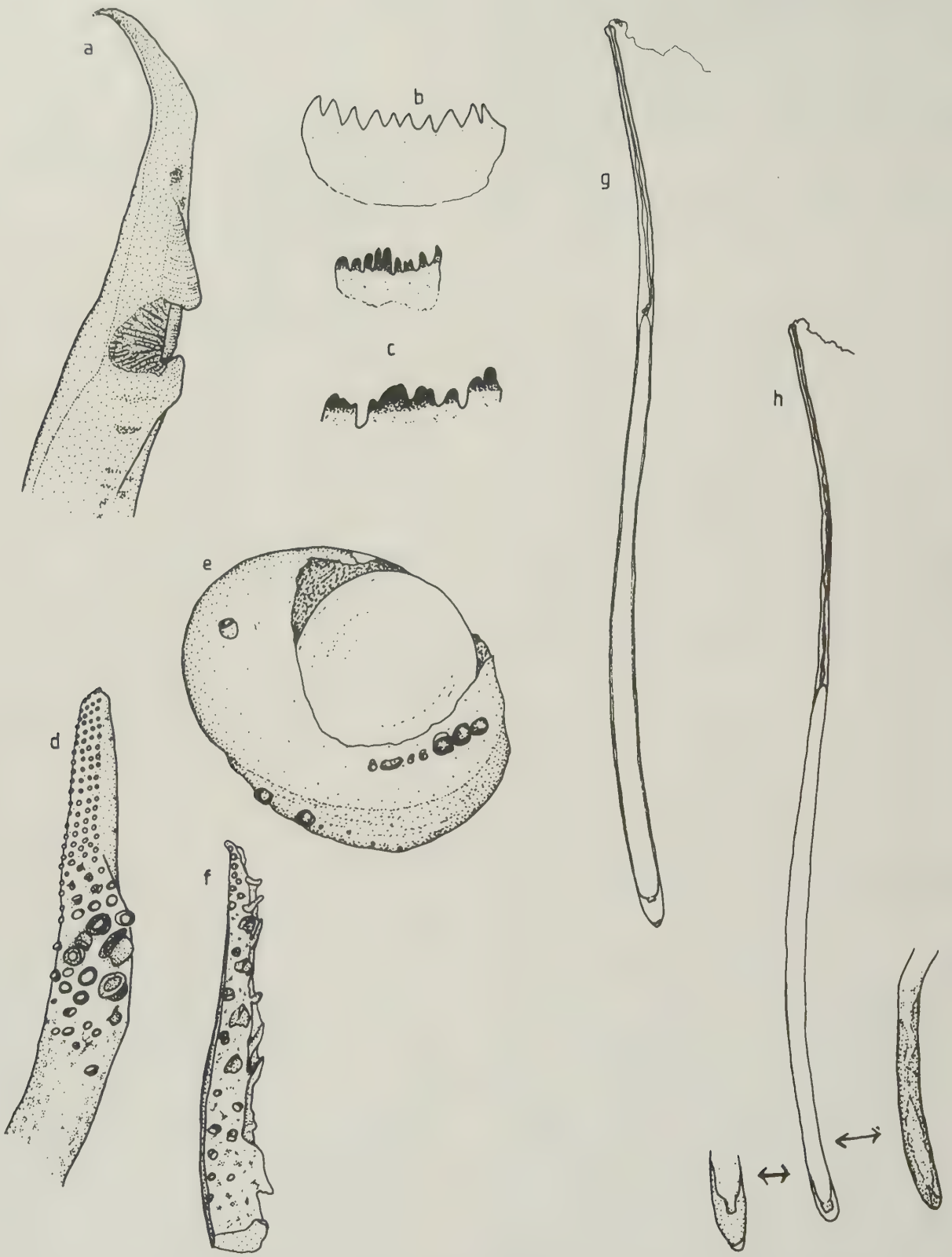


Fig. 11: a, *Pterygioteuthis gemmata* hectocotylus; b, plate from hectocotylus pocket of *P. gemmata*; c, plates from hectocotylus pockets of *P. microlampas*; d, *P. gemmata* right tentacular club; e, *P. gemmata* photophores of right eye (ventral view); f, *P. gemmata* left arm II; g, *P. gemmata* spermatophore (length 4 mm); h, *P. microlampas* spermatophores, showing variation in tips.

to do this and now believes that *P. microlampas* is a valid species, chiefly because it is so much smaller than *P. gemmata*, though he has not made the detailed systematic comparisons to prove it (Young pers. comm.). The species has, however, been referred to by this name in a number of papers (Arnold and Young 1974, Arnold, Young, and King 1974, Young 1977, Young *et al.* 1979) on bioluminescence. Its abundance, and the complex structure of its photophores, make it an interesting animal for research.

Since no one has adequately worked out the taxonomic status of this species, I have attempted to do so. Dr Roper has kindly lent me some *P. microlampas* from Hawaii: these were indistinguishable from specimens collected north of 28° S, which I had previously assigned to *P. gemmata*, but were rather different from *P. gemmata* specimens from further south.

The first characters examined were those which Berry (1914a) considered distinctive, namely the arrangement of the ocular photophores, the number of hooks on the arms, the distribution of suckers on the ventral arms, and the number of suckers in the carpal cluster.

1. No difference could be found in the arrangement of the ocular photophores (except that one specimen had an extra minute photophore on one eye, which gave it the same arrangement as in *P. giardi*). The displacement of the minute photophore on Berry's specimen must have been a result of damage (this often happens).
2. Female *P. microlampas* had between 9 and 19 hooks in total on the lateral arms, which overlaps considerably with *P. gemmata*. Males, however, had only 6 to 12 lateral arm hooks, which is mostly outside the known range for *P. gemmata* (Young 1972) and completely outside the range of the New Zealand sample (Fig. 12).
3. A few suckers are present on the proximal half of the ventral arms, though as with *P. gemmata* these are minute and hard to see and could easily have been overlooked by Berry.
4. The suckers in the carpal cluster are apparently easily lost. Specimens were seen without suckers or with one, two, or three. Berry believed that *P. microlampas* had two. Occasionally, *P. gemmata* may also have two (Young 1972).

The hectocotyluses and spermatophores of the males were also examined. The hectocotylus of *P. microlampas* is similar to that of *P. gemmata*, but the toothed plate is rather different. The local *P. gemmata* have a plate which is transparent and has about 10 even, triangular teeth on it. The lower (aboral) part of the plate of *P. microlampas* is transparent, but the teeth themselves are irregular, very variable, and black (Fig. 11c).

The spermatophores of *P. microlampas* are distinctly smaller (less than 3 mm long, compared with 4 mm for *P. gemmata*), but show no other constant morphological differences. The aboral end of the sperm mass appears to be rather variable (Fig. 11h), but this may be due to the action of the preservative on these very delicate structures.

The differences between *P. microlampas* and *P. gemmata* are therefore very small. They are:

1. *Pterygioteuthis microlampas* is much smaller. Females mature at about 20 mm ML, males at about 17 mm ML. The maximum mantle length (female) is about 23 mm. Fourteen ripe females measured in this study ranged from 18 to 23 mm ML. Ten mature *P. gemmata* females ranged from 26 to 31 mm ML, and the maximum size reached is 32 mm ML (Young 1972).
2. There is a sexual dimorphism in hook number in *P. microlampas*, but not in *P. gemmata*. Females are indistinguishable on hook numbers (Fig. 13), but males are very different.
3. There is a difference in the hectocotylus plate.

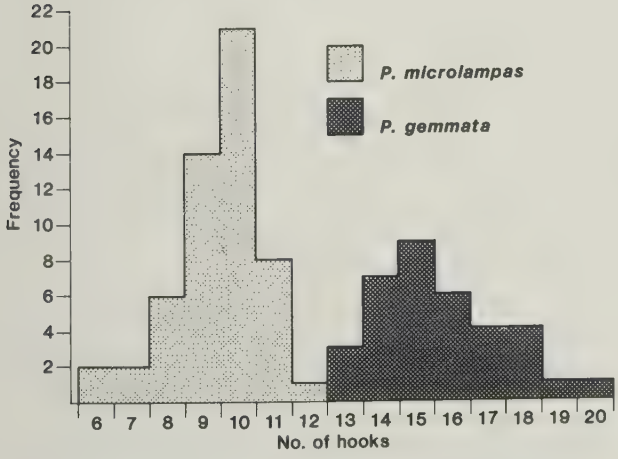


Fig. 12: Number of hooks on lateral arms of male *Pterygioteuthis microlampas* and *P. gemmata*.

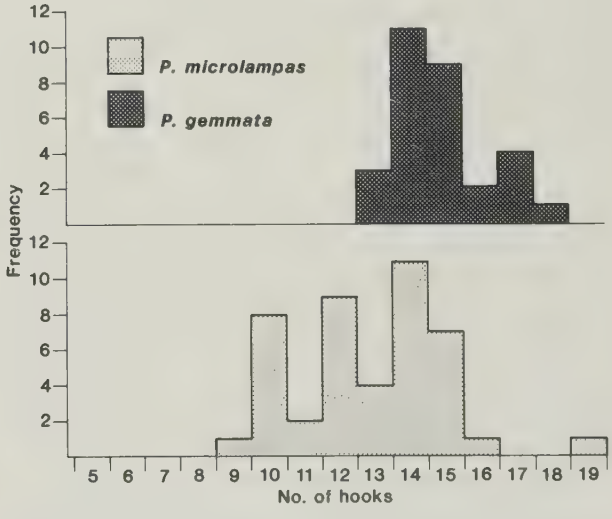


Fig. 13: Number of hooks on lateral arms of female *Pterygioteuthis microlampas* and *P. gemmata*.

All well preserved males above 13 mm and all females above about 18 mm ML could, therefore, be positively identified to one form or the other. When the geographical ranges were plotted (Fig. 9) it was found that *P. microlampas* occurs to the north of *P. gemmata*, with a narrow zone of overlap between the two at about 28° S, which probably coincides with the position of the Tropical Convergence (Heath 1973). The Tropical Convergence is, at least some of the time, not at all well developed north of the Kermadecs (Ridgway and Heath 1975), and so the overlap zone may occasionally be broader than is shown in Fig. 9. There is no evidence of hybridisation in this zone or anywhere else, and the two forms give every indication of being discrete entities. It must be concluded, therefore, that in spite of the small morphological differences, *P. microlampas* and *P. gemmata* are separate species.

There is one further problem. Young (1972) has shown that *P. gemmata* from the north-east Pacific have a different number of lateral arm hooks (mean 21.1) from the *P. gemmata* of the North Atlantic (mean 15.2). The local form has a mean number of 15.3, though *P. gemmata* specimens from the South Pacific which Young examined had a mean of 17.3. In addition, there are differences in the hectocotylus plates of the northern and southern Pacific forms. The northern form has a dark plate with usually nine irregular teeth (Young 1972). These differences are small, but they concern two of the characters used to distinguish *P. microlampas* from *P. gemmata*. Nonetheless, they are probably best regarded as geographical variations. Size differences such as that which so readily distinguishes *P. microlampas* from *P. gemmata* are not apparent, and by themselves the differences mentioned above would not justify splitting *P. gemmata* into two or more species.

Genus *Enoploteuthis* Orbigny, 1848

Enoploteuthis galaxias Berry, 1918 (Fig. 14)

Enoploteuthis galaxias Berry, 1918 pp. 211–21, figs. 1–4.
Euoploteuthis galaxias Cotton, 1942 p. 84.

Material examined: 1 female ML 68.4 mm J7/59/80; 1 female ML 61.2 mm J11/102/80; 1 female ML 38.6 mm J4/63/76; 1 male ML 59.3 mm J7/39/75; 1 male ML 45.6 mm J7/56/75; 1 male ML 35.8 mm J4/63/76; 1 juvenile ML 31.4 mm J11/99/76; 1 juvenile ML 29.6 mm J4/66/76; 1 juvenile ML 19.9 mm J7/23/75; 1 juvenile ML 19.7 mm J7/24/75; 1 juvenile ML 16.9 mm J12/58/75; 2 juveniles ML 8.7 mm, 6.3 mm J4/51/76; 1 female ML 116 mm F31261; 1 male ML 106 mm F31261 (from Sydney Head, New South Wales).

Detailed measurements of some specimens are given in Table 2.

This distinctive species was described thoroughly by Berry (1918) from four specimens taken off Victoria, Australia, and for a full description his paper should be consulted. All of Berry's specimens had mantle lengths of 72–87 mm. Now that a greater range of specimens is available some additional notes can be presented. Particularly important are the changes that occur with growth.

Mantle. Slender, with semi-gelatinous tail scarcely apparent in juveniles less than 30 mm ML (Fig. 15a), long and slender in adults.

Funnel organ. Lateral pads of dorsal component very long and narrow, bearing a distinct ridge (not an artifact of preservation as Berry suspected) along the anterior portion of each.

Eyes. Very large, sitting in sockets which are deeper than long. The unequal ocular development mentioned by Berry is not apparent.

Arms. Ventral edges of third arms with trabeculate membranes, more strongly developed in larger individuals. All protective membranes of specimens less than 60 mm ML approximately equally (and rather weakly) developed.

Hectocotylisation as described by Berry, not apparent in specimens less than 60 mm ML.

Mantle photophores. Juveniles: four well defined longitudinal rows on ventral surface of mantle, two or three organs deep, with a few scattered organs laterally. Subadults: in individuals larger than 30 mm ML, photophore rows become disrupted by evenly spaced outgrowths of photophores into clear spaces between rows (Fig. 15b); these occur first between the two median rows and begin anteriorly. Development and fusion of these outgrowths produces a ladder-like, then reticulate, pattern, the original longitudinal pattern being obscured.

Spermatophores. Relatively large (16 mm) for an enoploteuthid. Sperm mass extending from aboral tip for about 40% of spermatophore's length. Cement gland and collars very complex. Spiral filament and its sheath simple, except at oral tip, where sheath expands slightly and filament coils loosely (Fig. 15f).

Distribution

Berry (1918) found this species between 160 and 250 fathoms (293 and 457 m) in the region of Cape Everard, Victoria. Cotton (1942) recorded a single juvenile female of approximately 36 mm ML taken nearby at 38° S, 149° 23′ E from 200 m. They have also been taken from Sydney Head, New South Wales, in 400 m (Lu pers. comm.).

No specimens have been collected south of East Cape on the east coast (Fig. 16), though why this should be so is uncertain. The species appears to be reasonably common in the Bay of Plenty (compare distribution of *Abraliopsis gilchristi*) and seems to be associated with the continental slope (Fig. 17), though the two specimens taken on the west coast were in much deeper water.

Fig. 14: *Enoploteuthis galaxias*, ML 59.3 mm, male.

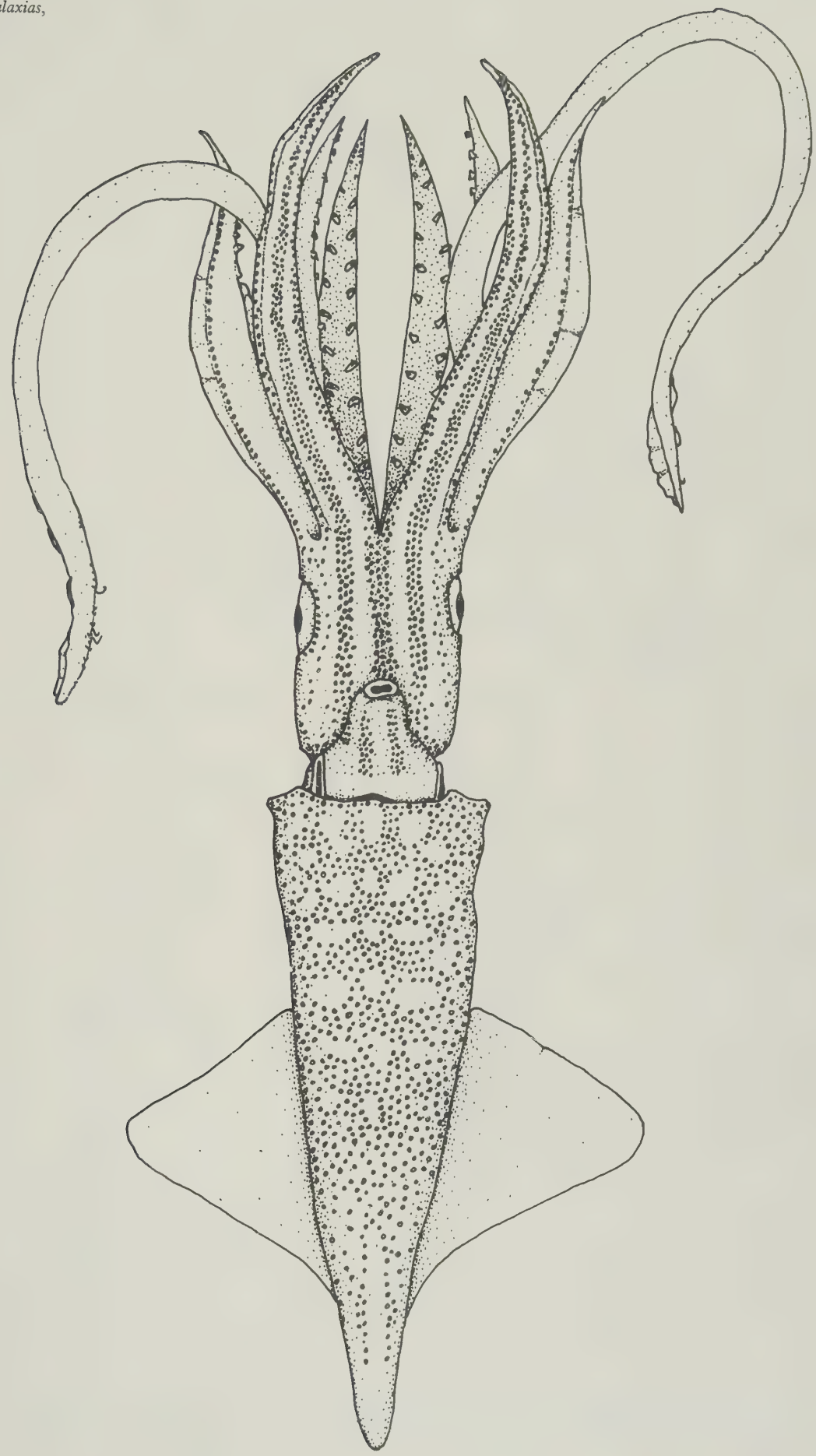


Fig. 15: *Enoploteuthis galaxias*: a, mantle of juvenile, ML 19.7 mm; b, mantle of subadult, ML 29.6 mm; c, head, lateral view, right side; d, left tentacular club; e, hectocotylus, mature male; f, spermatophore (length 16 mm).

TABLE 2: Measurements of *Enoploteuthis galaxias*

Sample No.		F31261	F31261	J7/39/75	J7/56/75	J7/3/76	J4/63/76
Sex		F	M	M	M	F	M
ML		117	106	59	45	39	36
MW		31	27	19	14	14.8	12
Tail LI		27	21	17	20	15	11
FLI		44	44	46	39	51	51
FWI		62	58	74	66	77	82
HL		32	31	19.5	15.5	15.5	13.6
FuL		20	21	10.8	7.8	8.1	7.9
ALI. I	l.	54	58	52	62	60	64
	r.	56	59	64	62	62	67
ALI. II	l.	61	65	73	65	71	77
	r.	58	66	73	68	72	76
ALI. III	l.	58	64	72	68	64	78
	r.	58	64	73	68	69	73
ALI. IV	l.	63	73	80	73	74	80
	r.	64	70	80	73	74	75
TLI	l.	132	139	145	100	109	117
	r.	147	138	141	123	113	125
CL	l.	25.8	24.8	12.2	12.7	11.5	10.2
	r.	26.0	24.9	12.2	13.6	12.3	10.5
AC. I	l.	31	25	26	21	23	21
	r.	31	26	25	23	22	22
AC. II	l.	33	28	28	22	24	23
	r.	33	27	27	22	24	23
AC. III	l.	32	28	29	26	24	23
	r.	33	29	29	26	23	22
AC. IV	l.	34	31	31	30	29	25
	r.	35	28	30	28	28	26

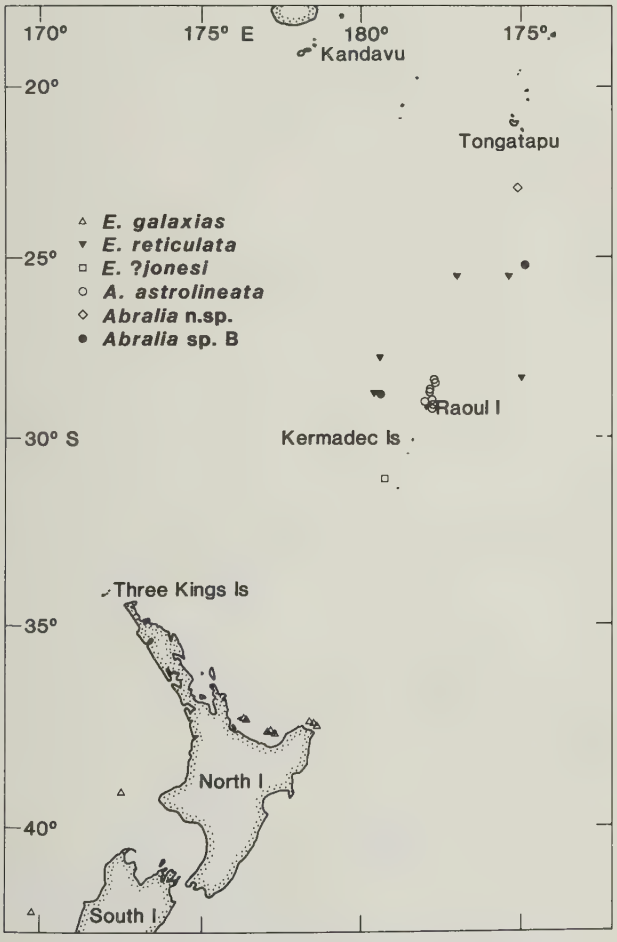


Fig. 16: Distribution of *Enoploteuthis* and *Abralia* spp.

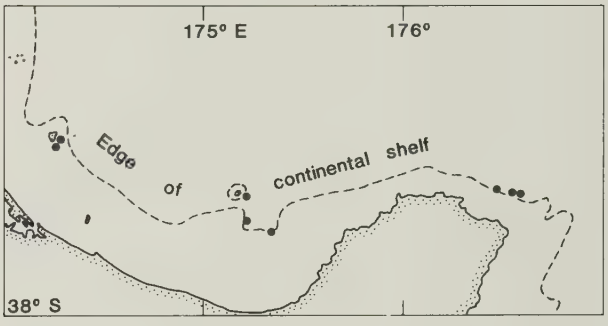


Fig. 17: Distribution of *Enoploteuthis galaxias* in Bay of Plenty.

The beaks found in petrel stomachs and assigned to *Lycoteuthis diadema* by Imber (1975) are in fact from mature *E. galaxias* (Imber pers. comm.). *Enoploteuthis galaxias* is thus an important food for the black petrel (*Procellaria parkinsoni*) and possibly other sea birds as well, and it must be much more common than present catch records indicate.

Enoploteuthis reticulata Rancurel, 1970 (Fig. 18)

Enoploteuthis reticulata Rancurel, 1970 pp. 45–51, figs. 31–37.
Enoploteuthis sp. (No. 1) Okutani, 1974 figs. 12 a, b, e.
Enoploteuthis sp. A Young, 1978 figs. 9B, 10A.
Enoploteuthis reticulata Burgess 1982 pp. 723–7, figs. 5, 6B.

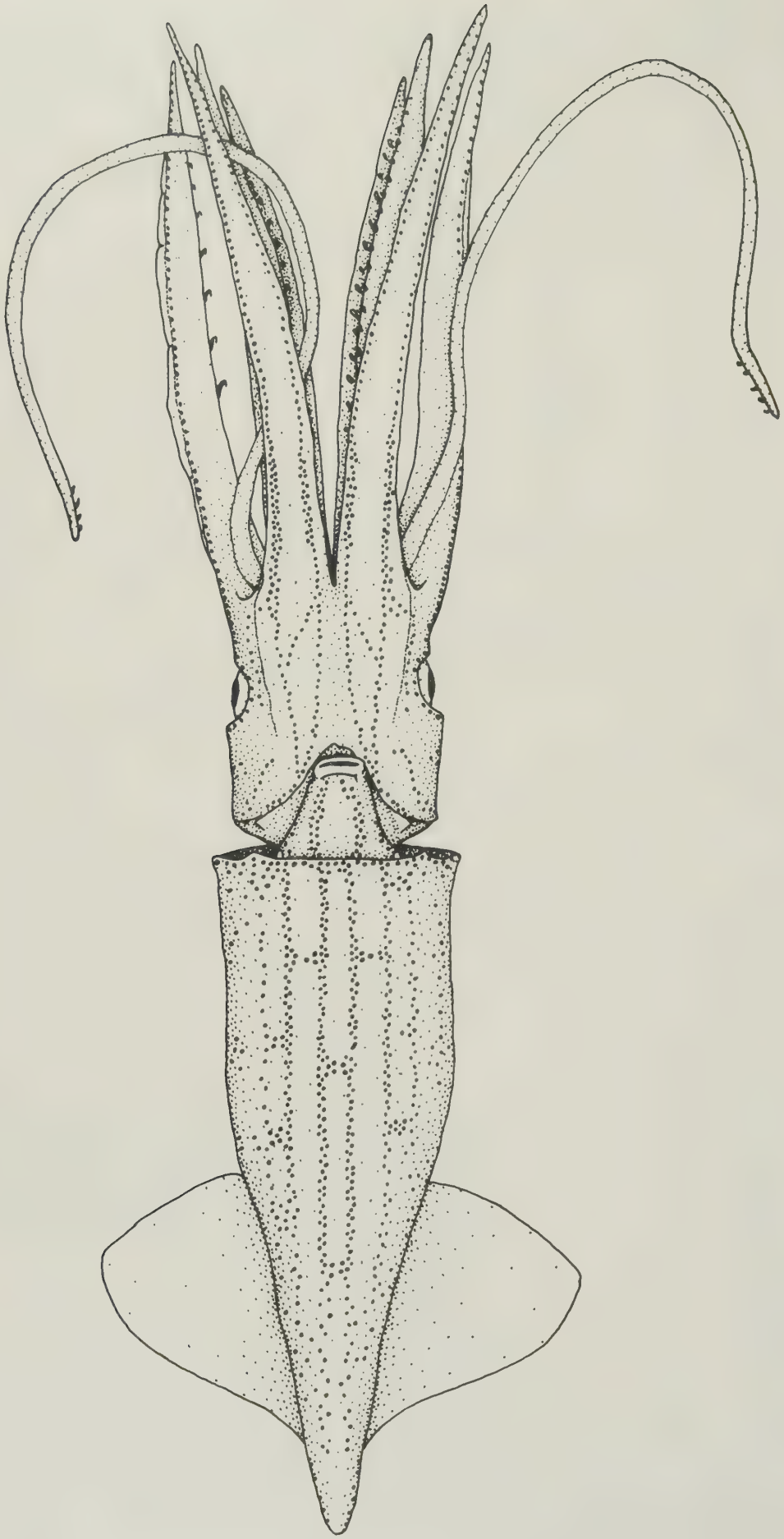


Fig. 18: *Enoploteuthis reticulata*, ML 45.4 mm, male.

Material examined: 2 males ML 46.7 mm, 33.3 mm J9/54/76; 1 female ML 45.4 mm J17/71/76; 3 juveniles ML 26.1 mm, 16.1 mm, 10.4 mm J17/65/76 (poor condition); 2 juveniles ML 34.5 mm, 33.8 mm J17/39/76 (poor condition); 1 juvenile ML 13.2 mm J9/45/76; 1 juvenile ML 17.2 mm J17/58/76.

Detailed measurements of some specimens are given in Table 3.

This distinctive species has only recently been fully described in English by Burgess (1982). A full description need not therefore be given here; the following characters should permit positive identification.

Tentacles. Slender, quite short. Clubs not expanded, bearing 2 rows of 6 or 7 hooks on manus, 5 or 6 suckers and pads in carpal cluster, about 10 suckers in 2 rows on very short dactylus. Ventral hooks of manus somewhat larger than dorsal hooks, median hooks of both rows larger than those proximally and distally (Fig. 19c).

Photophores. Eight longitudinal rows on ventral surface of mantle, outer pair uniserial, poorly defined, others roughly biserial, relatively straight. For purposes which will become apparent these can be labelled pairs I–IV, starting from the median pair and working outwards. One row of well spaced organs

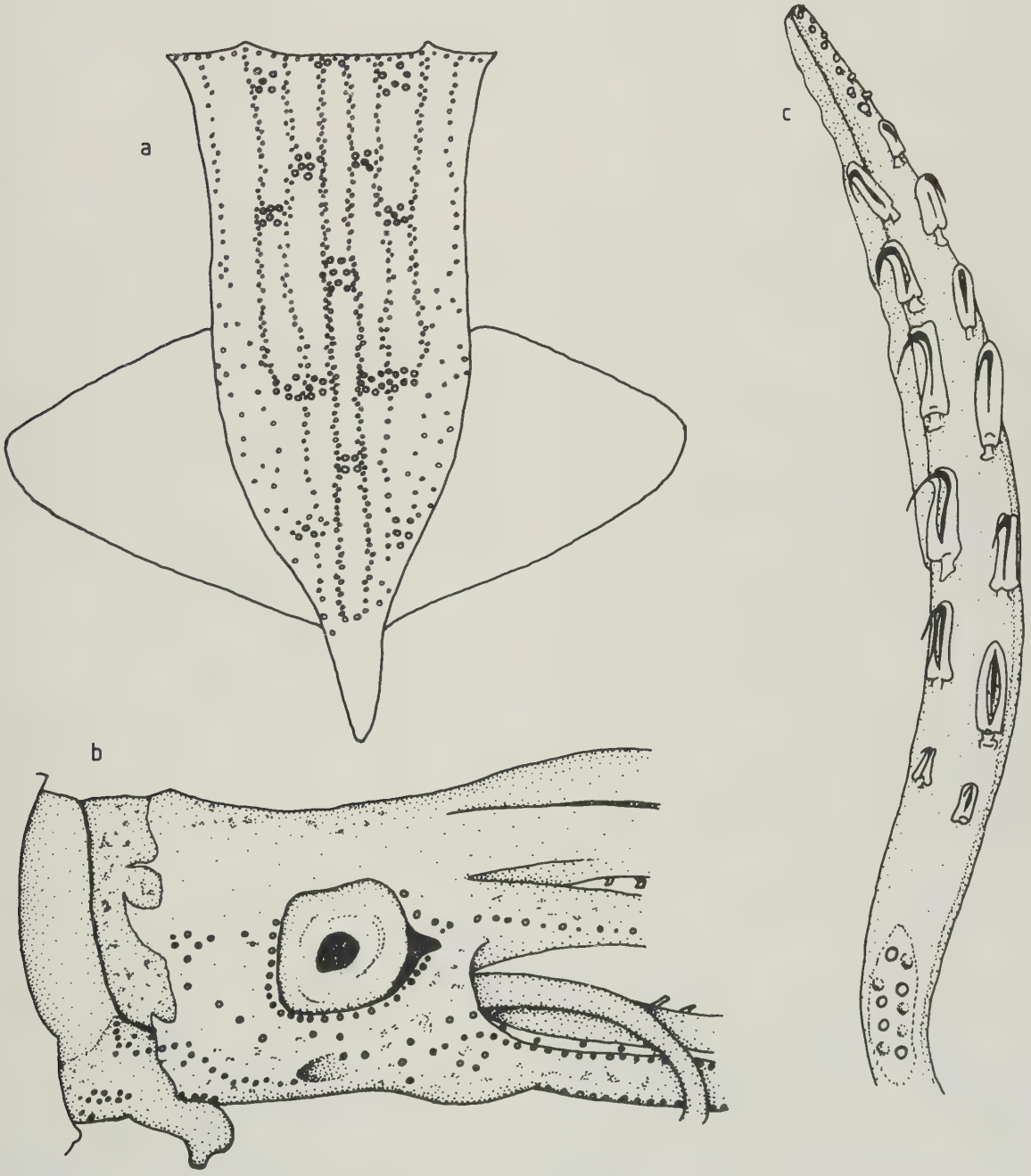


Fig. 19: *Enoploteuthis reticulata*: a, mantle of subadult; b, head, lateral view, right side; c, left tentacular club.

extending down either side of tail. A uniserial row around anterior mantle margin reaching three-quarters of way round to dorsal midline on each side.

Symmetrically arranged patches of larger, darker photophores present between rows, arranged as follows:

1. one between median rows (I) at anterior mantle margin;
2. one between rows I about half way between mantle margin and base of tail;
3. one half way between patch 2 and base of tail;
4. a pair between rows I and II at a level half way between patches 1 and 2;
5. a pair between rows III and IV just posterior to mantle margin;
6. a pair between rows III and IV at a level half way between patches 2 and 3;
7. a pair between rows III and IV at a level half way between patches 2 and 4;
8. a diffuse pair between rows III and IV at a level just posterior to patch 3.

About three more ill-defined patches and a few scattered organs dorsad of row IV.

In young specimens the patches predominate, and the rows may be scarcely apparent. As the animal grows, the pigmentation of the patches decreases and the rows become wider and more prominent (Figs. 18, 19a, 20).

Four rows on funnel, median pair roughly biserial, 17 organs each; each lateral row with only 5 or 6 organs. A patch dorsally on each side where funnel is attached to head.

Eight uniserial rows on ventral surface of head. Median pair running from near base of ventral nuchal crest anteriorly and along inner edge of ventral arms. Rows immediately laterally arising on each side from the median rows at about level of funnel tip, running anteriorly to level of anterior edge of eye socket, then bifurcating; one branch rejoining median row at base of arm IV, the other continuing up outer edge of arm IV to tip. Next row beginning near first at nuchal crest, interrupted by ventral window of eye, over which there are no photophores, then continuing to join second row at base of arm IV. Outermost row running around ventral eyelid. Another row beginning just dorsal to sinus of eye socket and running along ventral side of arm III at base of keel. An indefinite series extending a short way along outer edge of lateral webbing of arm IV. About 8 organs in small patch just posterior to eye.

Distribution

Rancurel (1970) recorded specimens from the stomachs of lancet fish (*Alepisaurus ferox*) taken widely in the south-western Pacific. Burgess (1982) reported the species from around and north of Hawaii. The New Zealand specimens come from north of Raoul Island, between 25° S and 28° S (Fig. 16), thereby extending the known range southwards. Presumably the species is widely distributed in the tropical Pacific.

The New Zealand specimens were taken at night in non-closing nets fished at depths of 20 to 94 m. Around Hawaii this species has been taken close to the surface (50–100 m) at night and much deeper (500–600 m) during the day (Burgess 1982).

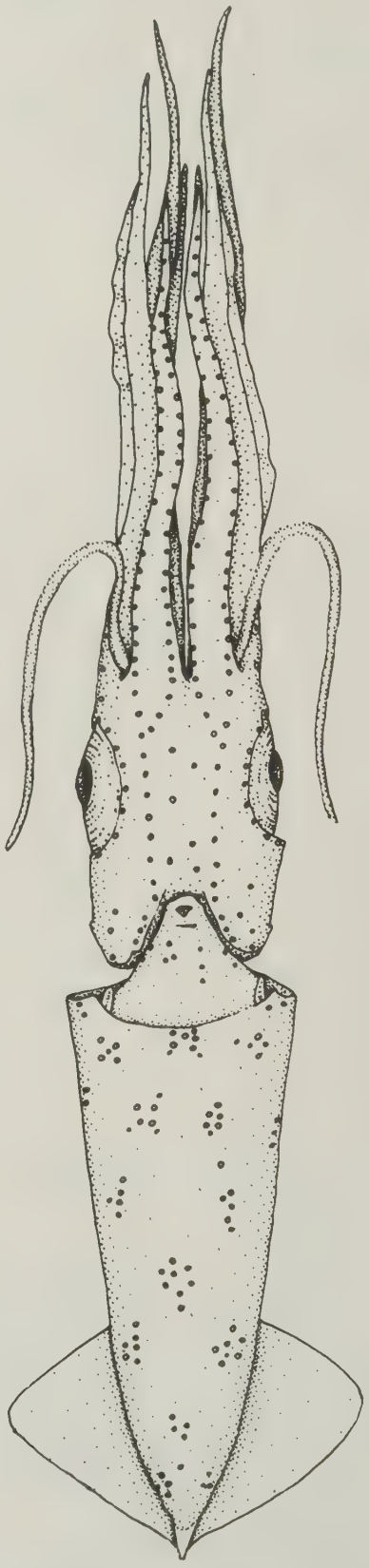


Fig. 20: *Enoploteuthis reticulata*, ML 17.2 mm, juvenile.

TABLE 3: Measurements of *Enoploteuthis reticulata*

Sample No.		J17/58/76	J17/71/76	J9/54/76	J9/54/76
Sex		-	F	F	M
ML		17.2	45.4	46.7	30.3
MW		5.9	14.8	15.7	12.0
FLI		38	37.4	33.8	39.6
FWI		55.0	72.7	77.1	81.2
Tail LI		9	19.8	30.0	14.8
HW		5.1	25.3	23.1	17.2
ALI. I	l.	87	76.6	77.1	95.7
	r.	81	79.7	79.4	95.0
ALI. II	l.	98	82.6	85.6	107.2
	r.	108	85.9	81.8	108.9
ALI. III	l.	87	81.2	85.5	99.0
	r.	86	79.1	85.0	100.6
ALI. IV	l.	81.83	83.7	85.2	96.7
	r.	81.3	85.2	99.0	-
TLI	l.	84	133	140	-
	r.	87	121	138	171
AC. I	l.	20	23	23	22
	r.	18	21	19	23
AC. II	l.	20	25	24	20
	r.	19	25	-	24
AC. III	l.	18	24	24	22
	r.	22	24	25	22
AC. IV	l.	25	32	32	28
	r.	25	32	-	31

Remarks

Well preserved specimens of this species are unlikely to be confused with any other species, with the possible exception of *E. galaxias* (see previous section for distinguishing characters). The juveniles appear very different from the adults, but they are still distinctive: no other enoploteuthid is known to have such a patchy arrangement of mantle photophores, though the juvenile of *Enoploteuthis octolineata* Burgess somewhat approaches this condition. The photophores of *E. reticulata* juveniles tend to be far less conspicuous than those of other enoploteuthids, however, so that in poorly preserved specimens they may be easily overlooked. In this respect the animals may not look like enoploteuthids at all, though other characters (for example, the hooks on the arms and clubs) clearly label them as such. Other than the photophore pattern, the clearest differences between juveniles of *E. reticulata* and other enoploteuthids are in their body proportions. Juvenile *E. reticulata* are slender, with long arms, short fins, and very small tentacles (Fig. 20). These characters give the animals an aspect quite different from any other known enoploteuthid.

The subsequent development of the mantle photophores, with the longitudinal lines becoming more apparent, is almost the opposite of what is seen in *E. galaxias*. Burgess (1982) has illustrated a specimen with a mantle length of 62 mm, which appears to have an essentially similar pattern to the 45-mm specimen illustrated here; so it would appear that this is the fully developed pattern, though the species grows to at least 130 mm ML (Burgess 1982).

The specimens examined agree closely with those described and figured by Rancurel (1970). The few differences from the type specimen (ML 27 mm) that can be noted in the larger individuals are clearly a result of the developmental changes described above.

***Enoploteuthis ?jonesi* Burgess, 1982** (Fig. 21)

Enoploteuthis jonesi Burgess, 1982 pp. 713–8, figs. 4, 2 D and F; table 3.

Material examined: 1 juvenile ML 11.6 mm J9/67/76.

The single, rather distorted juvenile specimen cannot be assigned with certainty to any known species. It is here tentatively placed in *E. jonesi* Burgess, 1982. The following characters distinguish it from the other known New Zealand *Enoploteuthis* species.

Fins. About half length of mantle, very broad. Posterior margins almost straight, anterior margins distinctly convex, tips rounded.

Tentacular club. At least three large hooks in ventral row of manus, at least two smaller ones in dorsal row. Several hooks apparently missing. Dactylus with four rows of minute suckers and a low, damaged membrane aborally. A short, low aboral flap running from level of most proximal remaining large hook to level of carpal cluster. Carpal suckers all missing.

Photophores. A series of organs three wide (outer row of organs still developing) running length of mantle, to either side of ventral midline. Laterally, separated from former series by a clear band, a uniserial row. A second uniserial row extending from level of funnel locking cartilage, both pairs of uniserial rows stopping short of mantle tip.

Funnel with two patches of photophores, five or six organs each, to either side of ventral midline. A single dorsal organ on each side.

Six or perhaps eight rows of photophores on head, with some organs developing between rows. Median

rows running anteriorly from funnel groove, apparently not on to ventral arms. (Much of the epidermis is missing from the arms.) Next rows laterally running along outer edges of ventral arms. Possibly an incompletely developed row interrupted by ventral window of eye. Outermost row running around ventral eyelid. Two organs on aboral surface at base of third arms.

Distribution

The single specimen was taken at 30° 54′ S, 179° 12′ W (Fig. 16) in a non-closing net trawled at night at a depth of 89 m. *Enoploteuthis jonesi* is known from a few widely spaced localities in the central Pacific from Hawaii to 15° S (Burgess 1982).

Remarks

This specimen clearly belongs in Burgess's "*E. anapsis*" species complex; that is, as with specimens of *E. anapsis*, *E. galaxias*, *E. chunii*, *E. jonesi*, and *E. higginsi*, it has long muscular tentacles with large clubs bearing many suckers in four rows on the dactylus, large hooks, and a semi-lunar membrane on the carpus. Its photophore pattern (as far as it can be made out) distinguishes it from the juveniles of all these species with the exception of *E. jonesi*. With few other characters to go on, it is probably best for now to regard it as belonging to this species.

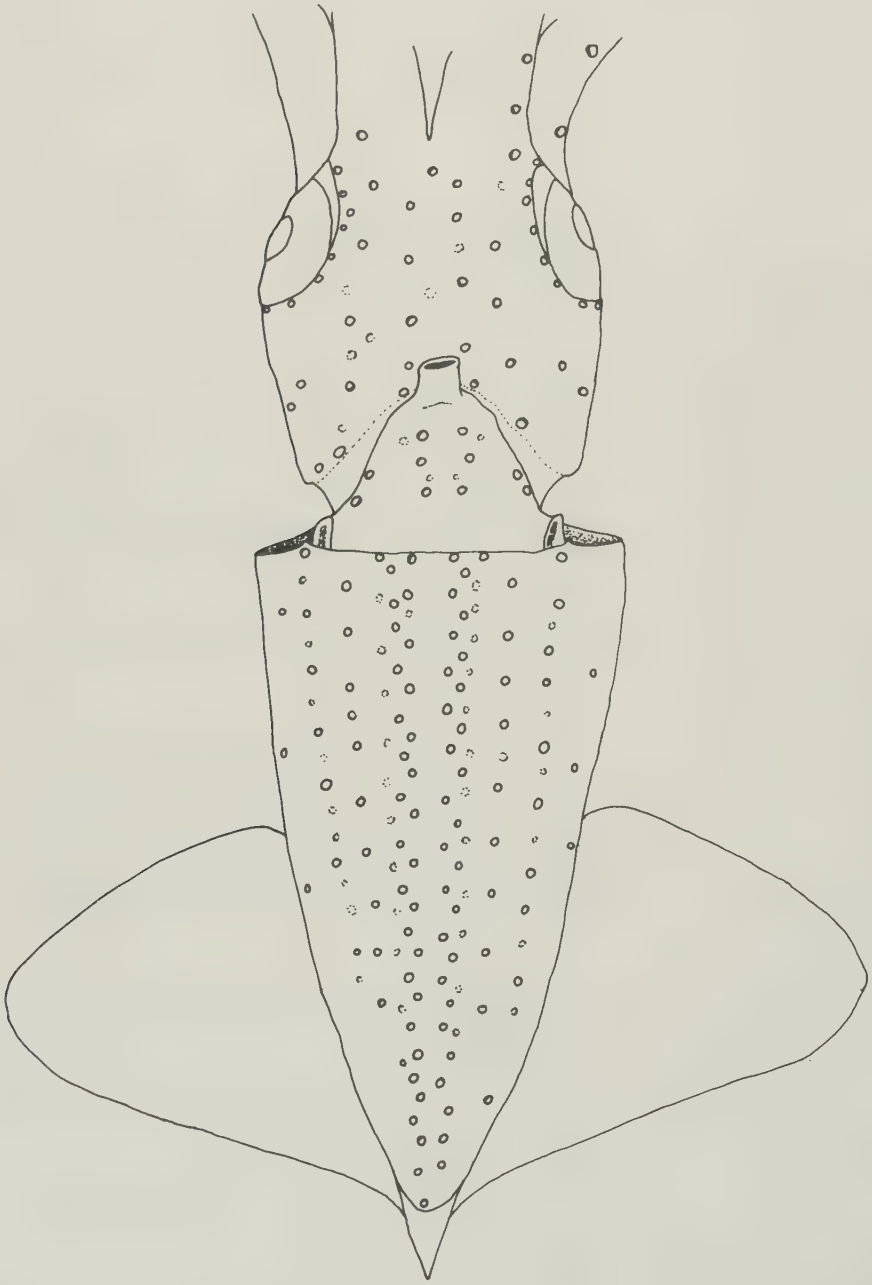


Fig. 21: *Enoploteuthis ?jonesi*, ML 11.6 mm, juvenile, showing distribution of photophores.

Genus *Abralia* Gray, 1849

Abralia astrolineata Berry, 1914 (Fig. 22)

Abralia astrolineata Berry, 1914 pp. 145–7, pl. X, figs. 1, 2.

Material examined: 8 females ML 41.4 mm, 39.6 mm, 39.5 mm, 38.1 mm, 36.1 mm, 35.2 mm, 33.8 mm, 33.0 mm J9/17/76; 3 females ML 52.1 mm, 40.7 mm, 44.7 mm J9/32/76; 1 female ML 44.8 mm J9/32/76; 1 female ML 37.1 mm (mantle only) J9/34/76; 6 males ML 37.2 mm, 36.1 mm, 33.2 mm, 33.0 mm, 33.0 mm, 31.0 mm J9/17/76; 5 males ML 37.6 mm, 37.1 mm, 37.0 mm, 36.0 mm, 30.1 mm J9/32/76; 1 male ML 36.9 mm (mantle only) J9/34/76; 14 juveniles ML 22.3 mm, 20.0 mm, 19.4 mm, 18.1 mm, 18.1 mm, 17.9 mm, 16.8 mm, 16.0 mm, 15.2 mm, 15.1 mm, 14.8 mm, 13.5 mm, 13.2 mm, 12.4 mm J9/17/76; 6 juveniles ML 21.8 mm, 20.5 mm, 19.9 mm, 19.8 mm, 18.1 mm, 14.0 mm J9/32/76; 6 juveniles ML 21.8 mm, 19.2 mm, 18.8 mm, 17.7 mm, 17.1 mm, 15.5 mm skipjack gut; 4 juveniles ML 20.0 mm, 17.6 mm, 16.3 mm, 13.5 mm J9/23/76; 2 juveniles ML 20.6 mm, 13.0 mm J9/34/76; 2 juveniles ML 16.8 mm, 11.9 mm J9/34/76; 1 juvenile ML 17.6 mm J9/23/76; 1 juvenile ML 17.4 mm J9/21/76; 1 head J9/19/76; 1 head J9/32/76; 1 head J9/36/76.

Only one specimen of this species, washed ashore on Raoul (Sunday) Island in the Kermadecs (Berry 1914b), has previously been collected. This was a female in remarkably good condition, and Berry described it in considerable detail. Except for a few notes on the males and juveniles of the species, little can be added to Berry's description. Some of the diagnostic characters, including the very distinctive photophore pattern, are described below, and these should permit positive identification of the species.

Mantle. Slender and muscular, with three small swellings at posterior tip. Lateral swellings pale, ventral one dark because of colour of gladius tip, which sits inside it.

Fins. 40–45% of mantle length, breadth 78–87% of mantle length.

Tentacular clubs. Four to five suckers and pads in carpal cluster. Four to five hooks in ventral row of manus, proximal hook rather smaller than others. Two rows of large suckers dorsad of these. Dactylus quite long, with four rows of minute suckers. A membranous keel aborally, running from tip of dactylus to about the level of third hook (Fig. 23b).

Photophores. Six very prominent rows ventrally on mantle: two median pairs three or four organs wide, outermost pair less distinct, only one or two organs wide. Numerous scattered organs laterally. A few organs in a pair of rows along either side of dorsal midline. A row almost entirely encircling mantle margin, stopping short of dorsal midline on each side.

On head, a prominent triserial mid-ventral row, bifurcating posteriorly and running a short distance either side of funnel tip, bifurcating anteriorly into two uniserial rows running along inner edges of ventral arms almost to tips. Lateral to mid-ventral row, two equally prominent rows running from base of ventral nuchal crest to about half way along middle of ventral arms. A uniserial row running from base of lateral nuchal crest along outer edge of ventral arms, almost to tips, interrupted by ventral window of eye. A row of about 47 organs extending around margin of eye socket (Fig. 24a). A short row running from just dorsad of sinus of eye socket for a short distance along arm III. Three small darkly pigmented organs at tip of each ventral arm, separated from other arm photophores.

Five large red photophores on ventral surface of eyeball.

Colour in preservative. Pale tan-brown, with patches of reddish brown chromatophores. Photophores dark, purplish.

Hectocotylus. On right arm of male; 12–14 little-modified hooks proximally, followed by 0–2 minute suckers. Distad of these, a high, fleshy membrane extending along ventral edge of oral surface for about one-tenth of arm's length. A much shorter dorsal membrane of about same height arising near distal end of ventral membrane. Oral surface of arm very narrow at this point, so that membranes are almost in contact with each other (Fig. 24b). No armature distally. Protective membranes rudimentary apart from enlarged sections described above.

Spermatophores. About 11 mm long, quite plump. Sperm mass extending to aboral tip, cement gland large. Spiral filament relatively short, with transverse striations (Fig. 24c).

The juveniles are similar to the adults, but there are a few differences. The mantle is more slender and the fins proportionately smaller. The photophore pattern is essentially the same, but the photophores tend to be fewer in number; there may be uniserial rows instead of triserial rows for instance, and the rows on the arms are not as long (Fig. 23a). The terminal photophores of the ventral arms are present and are relatively larger than in the adults. As well as the abundant minute photophores, there are several rather larger organs, with white centres, arranged in a definite pattern. Although these are present on the adults, they are more obvious on juveniles.

Distribution

Abralia astrolineata has probably the most restricted range of any New Zealand enoploteuthid. The 58 specimens for which accurate information on locality of capture is available come from an 80-km strip along the Kermadec Ridge from Raoul Island northwards (Fig. 16). With the exception of J9/36/76 and J9/21/76, all the capture sites had a minimum bottom depth of less than 300 m: the single head of J9/36/76 could be a contaminant from a previous

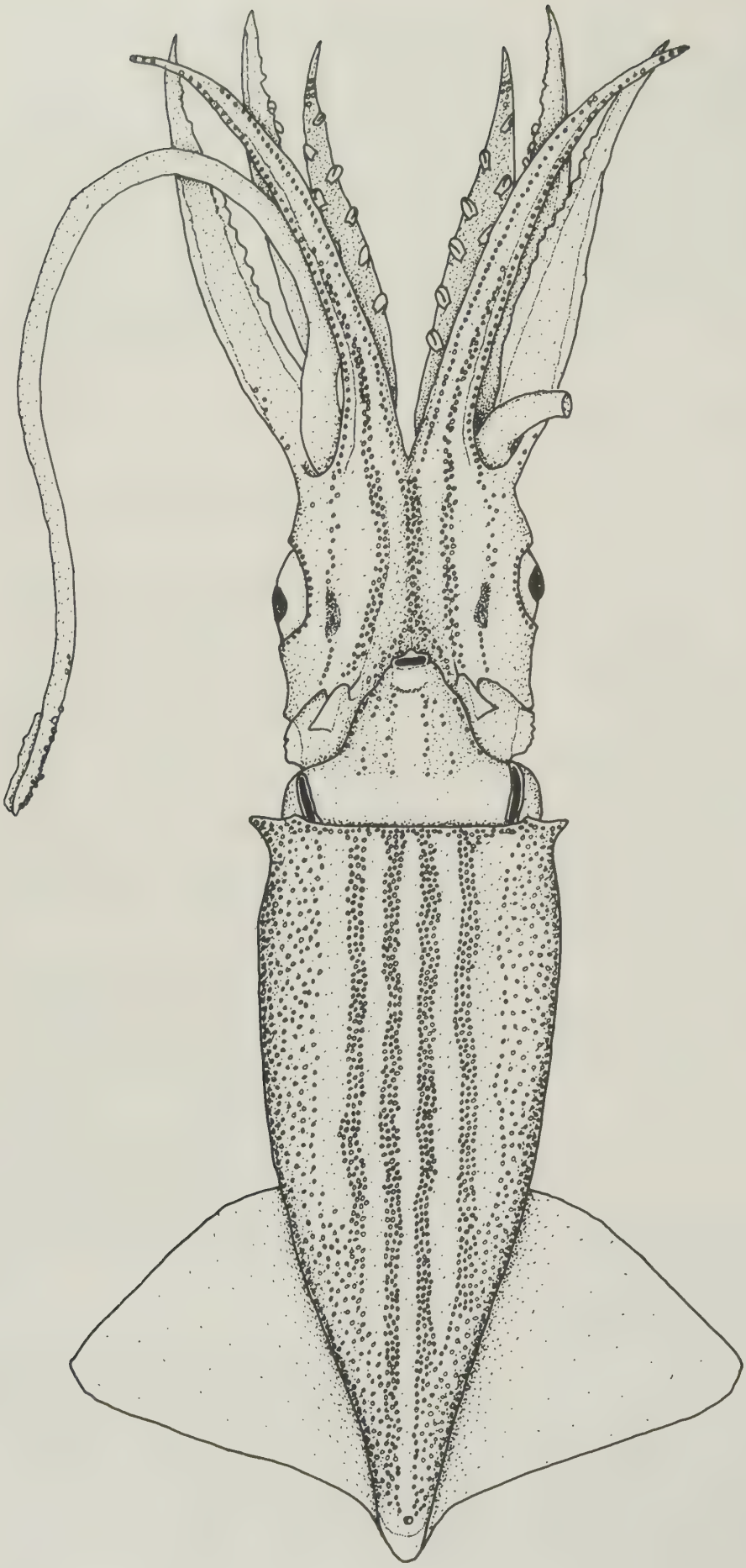


Fig. 22: *Abralia astrolineata*, ML 52.0 mm, female.

trawl, and the single juvenile of J9/21/76, though taken at a bottom depth of 616–890 m, may have been associated with the shallow ground close by. In view of its abundance in this area and its apparent absence from deep water nearby (Fig. 25), *A. astrolineata* may be considered a (relatively) shallow-water species. This inshore distribution is unlikely to be a result of spawning aggregation, as many immature individuals were present. Much of the Kermadec Ridge is unstudied; further cruises may well find this species along the length of the ridge in depths of less than 300 m and possibly northwards around Tonga.

This species was taken at night from an open net trawled at depths of 18, 51, 80, 90, 162, and about 300 m, with most (74%) coming from 90 and 162 m. Six juveniles were taken from the gut of a skipjack tuna (*Katsuwonus pelamis*), caught at an unknown location. It is likely that *A. astrolineata* is at least partially benthic in habits during the day and comes up into the water column to feed at night. A rather similar species, *A. astrosticta* from Hawaii, is also believed to be associated with the bottom off oceanic islands and is probably even more benthic in habits than *A. astrolineata*, as adults have been taken only in bottom trawls (Roper and Young 1975).

Remarks

As Berry (1914b) put it: "In its general organisation *A. astrolineata* represents a type so different from all other *Abralias* as to scarcely require any special comparison with any of them." Berry particularly empha-

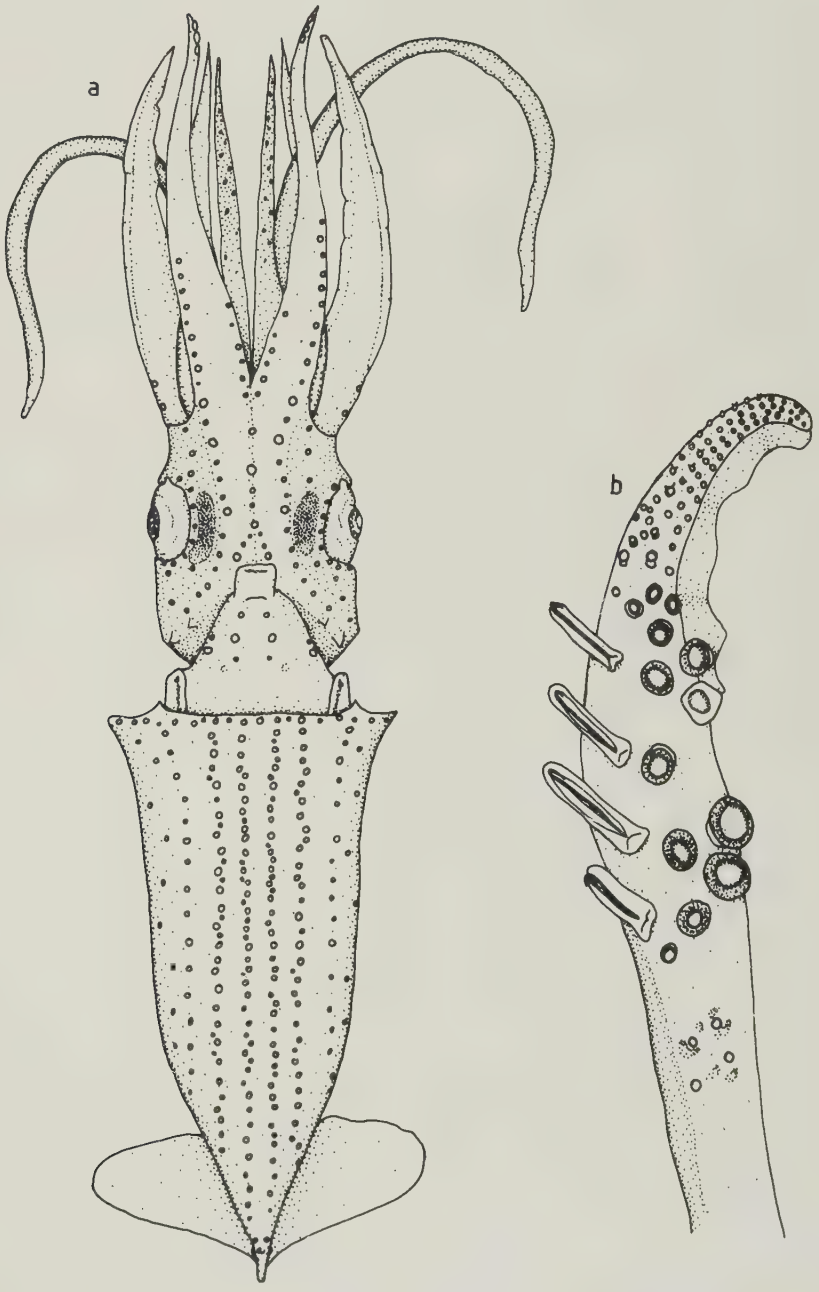


Fig. 23: *Abralia astrolineata*: a, juvenile, ML 17.8 mm; b, right tentacular club.

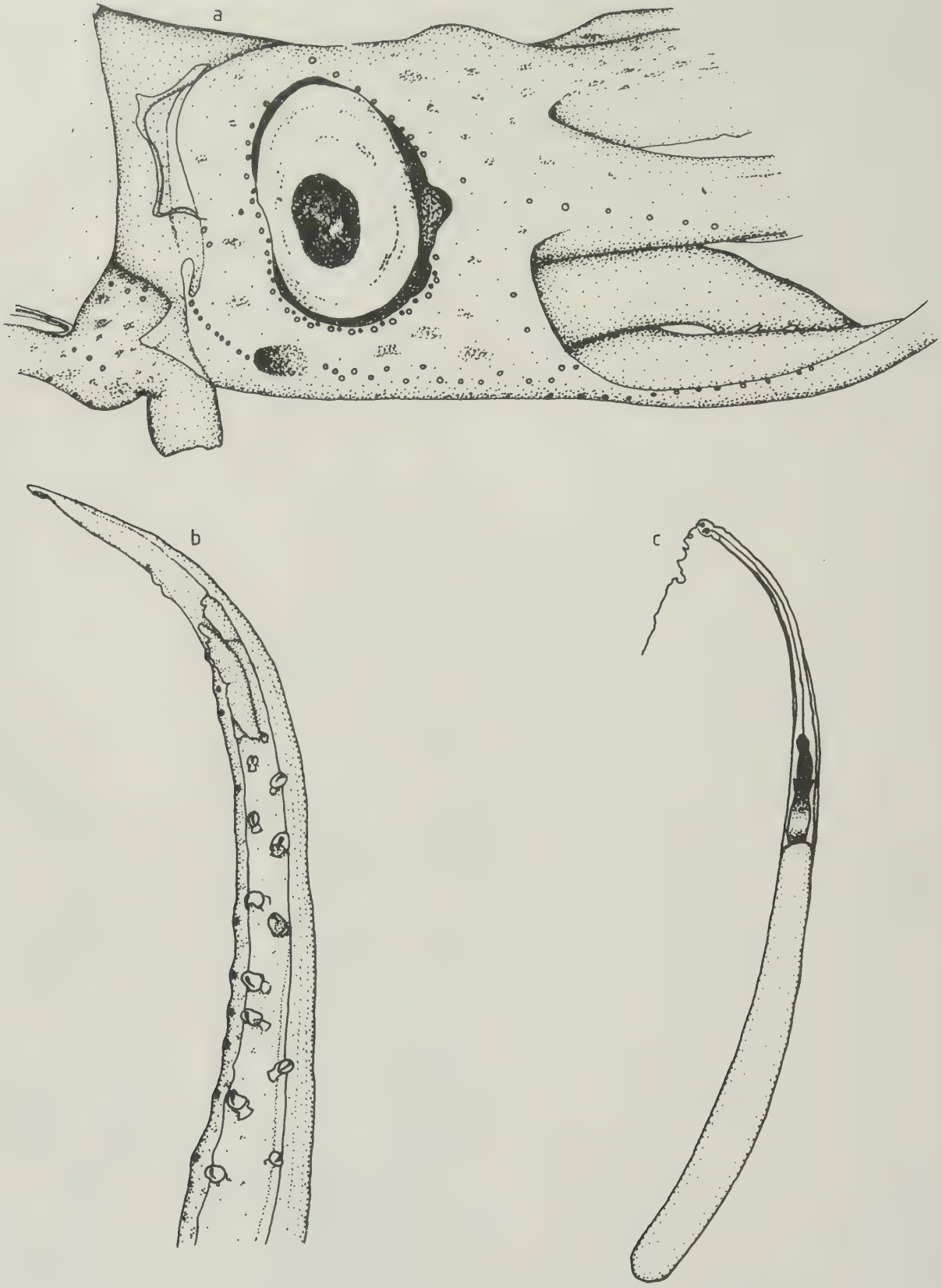


Fig. 24: *Abralia astrolineata*: a, lateral view of head, right side; b, hectocotylus; c, spermatophore.

sised the prominent banding of the photophores and the darkly pigmented terminal photophores of the ventral arms. The last characteristic is quite constant and is particularly obvious in juveniles. Although the photophores are not enlarged as in *Abraliopsis* and *Watasenia*, they are almost certainly homologous with the terminal photophores of these genera. Only one other *Abralia*, *A. redfieldi* Voss, 1955, is known to have comparable organs (Cairns 1976). Moreover, this species also has the right arm hectocotylised, has only five ocular photophores, and is the only other *Abralia* known to occasionally have suckers on the hectocotylus (this may be a subadult character). In other respects, however, it is quite different: in particular, it is of much stockier build and has a more uniform photophore pattern.

***Abralia* n.sp.** (Fig. 26)

Material examined: 1 female ML 23.6 mm J17/58/76.

This is yet another species represented in the collections by only one specimen. Moreover, through circumstances beyond my control, the specimen has been lost. Some notes and sketches made of it, however, allow it to be identified as a species previously collected by Burgess (pers. comm.). Much of what follows is based on her as yet unpublished material.

Mantle. Short, broad, conical.

Fins. Margins convex anteriorly, concave posteriorly, tips pointed. Length half that of mantle, width 90–100% of mantle length.

Funnel. Short, blunt tipped.

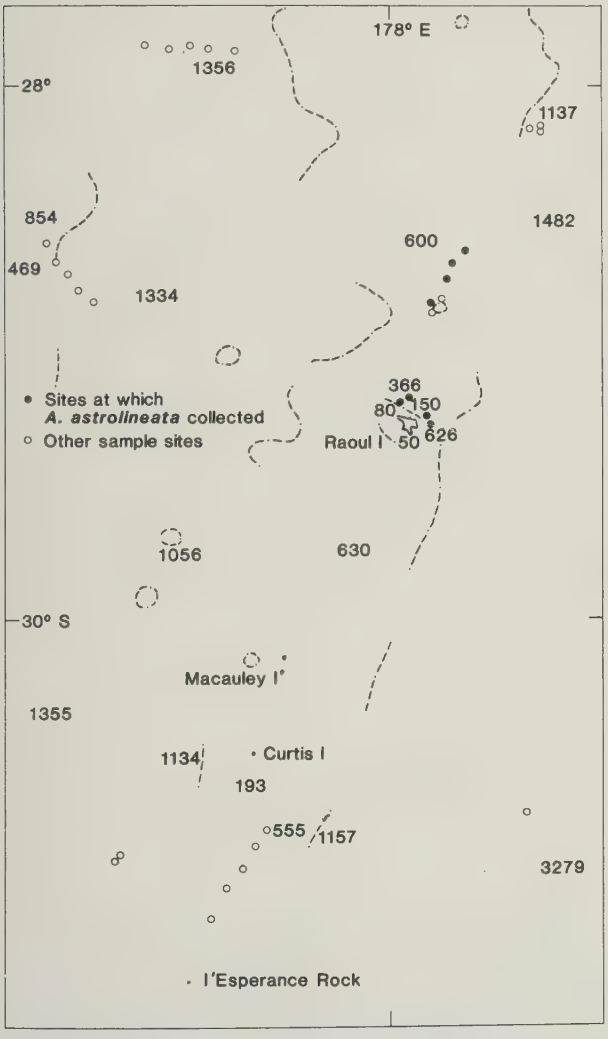


Fig. 25: Distribution of *Abralia astrolineata* along Kermadec Ridge.

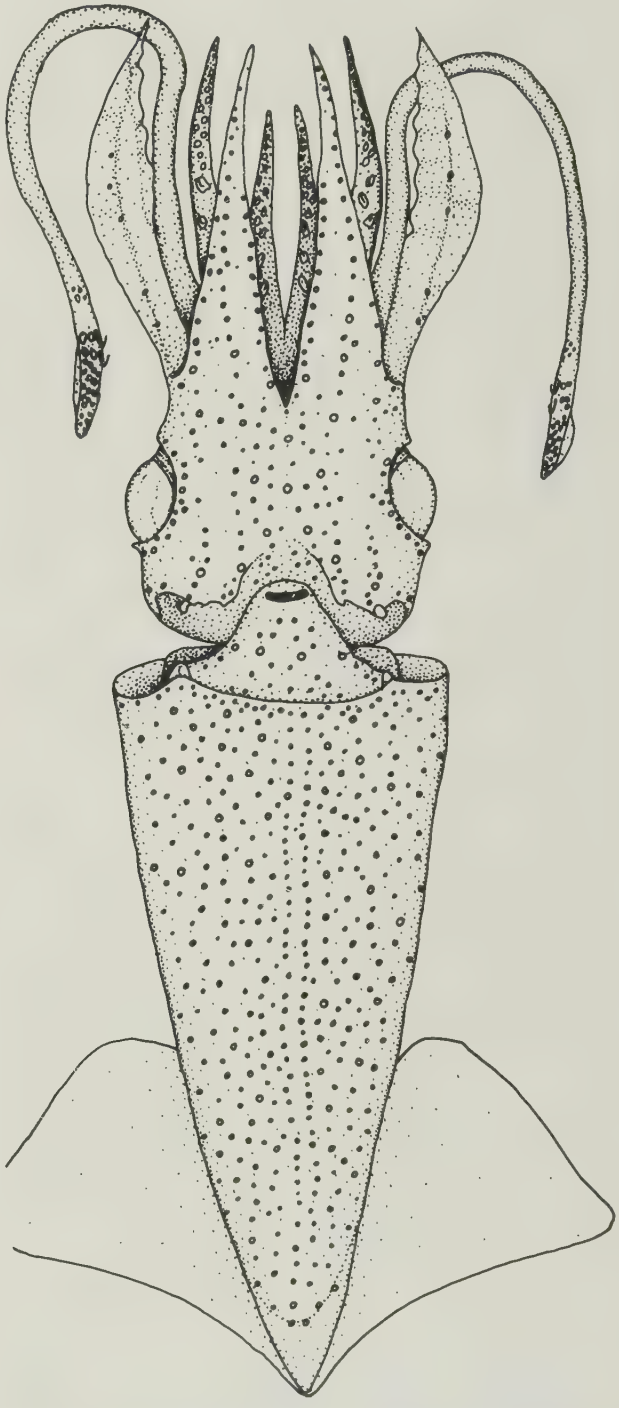


Fig. 26: *Abralia* n.sp., ML 28 mm, female (after Burgess).

Head. Squarish, less broad than mantle.

Arms. Short, subequal, dorsal arms shortest. Third arms keeled along entire length. Four to 8 hooks on dorsal arms, 6 to 10 on arms II and III, 8 to 12 on arms IV.

Hectocotylus. On right ventral arm of male. An enlarged membrane on ventral edge of oral surface extending from level of sixth hook two-thirds of way to arm tip. On dorsal edge a membrane extending from level of last hook to arm tip, widest in mid portion, tapering gently proximally and distally.

Tentacles. About twice as long as arms, slender, bearing clubs which are not expanded. Three to five suckers in carpal cluster, one or two hooks on manus ventrally, two rows of suckers dorsally. Dactylus long, with minute suckers in four rows. Aborally a broad membrane extending from dactylus tip to level of distal hook.

Photophores. Distributed almost uniformly over ventral surface of mantle, with a clear mid-ventral strip. Four large organs in transverse row on funnel, smaller organs scattered. On head, large organs arranged in distinct pattern, smaller organs scattered. A series around each eyelid, three uniserial rows extending along ventral arms, only median row reaching arm tip. A few organs in single row along ventral edge of keel on arm III. Five large, reddish photophores in single row along ventral surface of eyeball, the outer two being largest.

Colour. Uniformly dark purplish grey in preservative.

Distribution

The single specimen was taken at night in a non-closing net at a depth of 59 m at 22° 46′ S, 175° 02′ W (Fig. 16). Further details must await the publication of Burgess's material.

Remarks

The most distinctive character of this species is the low number of hooks on the clubs (one or two). The hooks are so small that they may be overlooked with the naked eye. One other species, *A. grimpei*, has only two hooks on the club, but it also has a flap in the carpal region, more photophores on the eyeball, and mantle photophores arranged in distinct longitudinal bands (Voss 1963). The form of the club, the arrangement of the photophores, and the general body proportions (broad mantle, short arms) easily distinguish the present species from the other two *Abralia* species known from this region. The low number of hooks on the arms (particularly on the dorsal pair) and the dark colour are also distinctive.

Abralia sp. B (Fig. 27a)

Material examined: 1 juvenile ML 13.8 mm J9/49/76; 1 juvenile ML 10.2 mm J17/65/76.

Only two specimens are present in the collections. Though in reasonably good condition, they are too small to identify, but clearly do not belong to either of the previous two species. They are described briefly below in the hope that they may be identified when adults are eventually collected.

Mantle. Very broad, sac-like, clearly juvenile in form.

Fins. Length about one-third that of mantle, breadth about the same as mantle length. Anterior and posterior margins convex, tips rounded.

Funnel. Very large, broader than head.

Arms. Very long, subequal. Order of length 4. 3 = 2. 1. Ventral arms about same length as mantle. Protective membranes rudimentary. A low keel on mid portion of aboral surface of arm III. Ventral arms with 16–17 hooks, other arms with 14–15. Ten small suckers in two rows distally on each arm. About seven triangular teeth around distal edge of each sucker.

Tentacles. About as stout as, and not much longer than, arms. Club very long, not expanded. Carpal suckers missing. Four hooks on manus in ventral row, about eight suckers dorsad of these. Presumably these are in two rows, though owing to the animal's small size and the narrowness of the club they are very closely packed. Four suckers proximally on manus. Dactylus very long, bearing four rows of minute suckers. A low keel aborally extending from dactylus tip to middle of manus (Fig. 27b).

Photophores. Numerous on ventral and lateral surfaces of mantle, few dorsally. Photophores of two sizes, tending to lie in indistinct uniserial longitudinal rows, otherwise showing no obvious pattern. About 15 organs distributed in apparently random fashion over anterior half of ventral surface of funnel. One large photophore on head to either side of funnel tip, another on midline near base of ventral arms, numerous smaller organs in no obvious pattern. A row of small organs around ventral eyelid. A uniserial row extending along each edge of ventral arms, almost to arm tips, outer rows slightly longer than inner. Nine large red organs in single row on ventral surface of eyeball.

Colour. In preservative, a uniform tan-brown.

Distribution

The two specimens were collected at 27° 50.8′ S, 179° 01′ W and 25° 25′ S, 175° 09′ W (Fig. 16) in a non-closing net fished at 45 and 48 m at night.

Remarks

This species is most easily distinguished from *A. astrolineata* by the more uniform distribution of the photophores. There are also probably some differences in body proportions: in particular the arms are remarkably long for an *Abralia* species, though the proportions of the adult may be quite different. From

Abralia n.sp. it may be distinguished by the higher number of hooks on the manus and on the arms. The uniform distribution of the photophores, the two rows of distal suckers on each arm, the number of arm hooks, and a club with a keel on the dactylus, five hooks on the manus, and no proximal aboral flap are characters which distinguish this species from most others in the genus. The present specimens probably belong to an undescribed species, but more *Abralia* specimens, particularly adults and subadults from the same region, will have to be collected to positively establish its identity.

It is possible that this species is actually an *Enoploteuthis*, as the ocular photophores are very similar to those of species of that genus. The lack of photophores on the dorsal eyelid is also an *Enoploteuthis*-like feature. The species is here placed in *Abralia* because there is only one row of hooks on the tentacular club; *Enoploteuthis* species have two. Juvenile *Enoploteuthis* may, however, have only one row (Roper 1966), though the second row has usually developed by the time they reach the size of the present specimens.

Genus *Abraliopsis* Joubin, 1896

Abraliopsis tui n.sp. (Fig. 28)

?*Abraliopsis hoylei* Berry, 1914 p. 148.

Material examined: 1 male ML 28.7 mm J17/71/76 (holotype); 1 male ML 29.5 mm J17/71/76 (paratype); 3 females ML 19.7–30.2 mm J17/71/76 (paratypes); 1 male ML 25.8 mm J9/41/76; 9 females ML 23.6–34.8 mm J9/41/76; 1 male ML 24.3 mm J9/41/76; 3 females ML 30.5–32.9 mm J17/10/76; 3 females ML 18.0–20.5 mm J17/22/76; 2 males ML

Fig 27: *Abralia* sp. B: a, ML 13.8 mm, juvenile; b, left tentacular club.

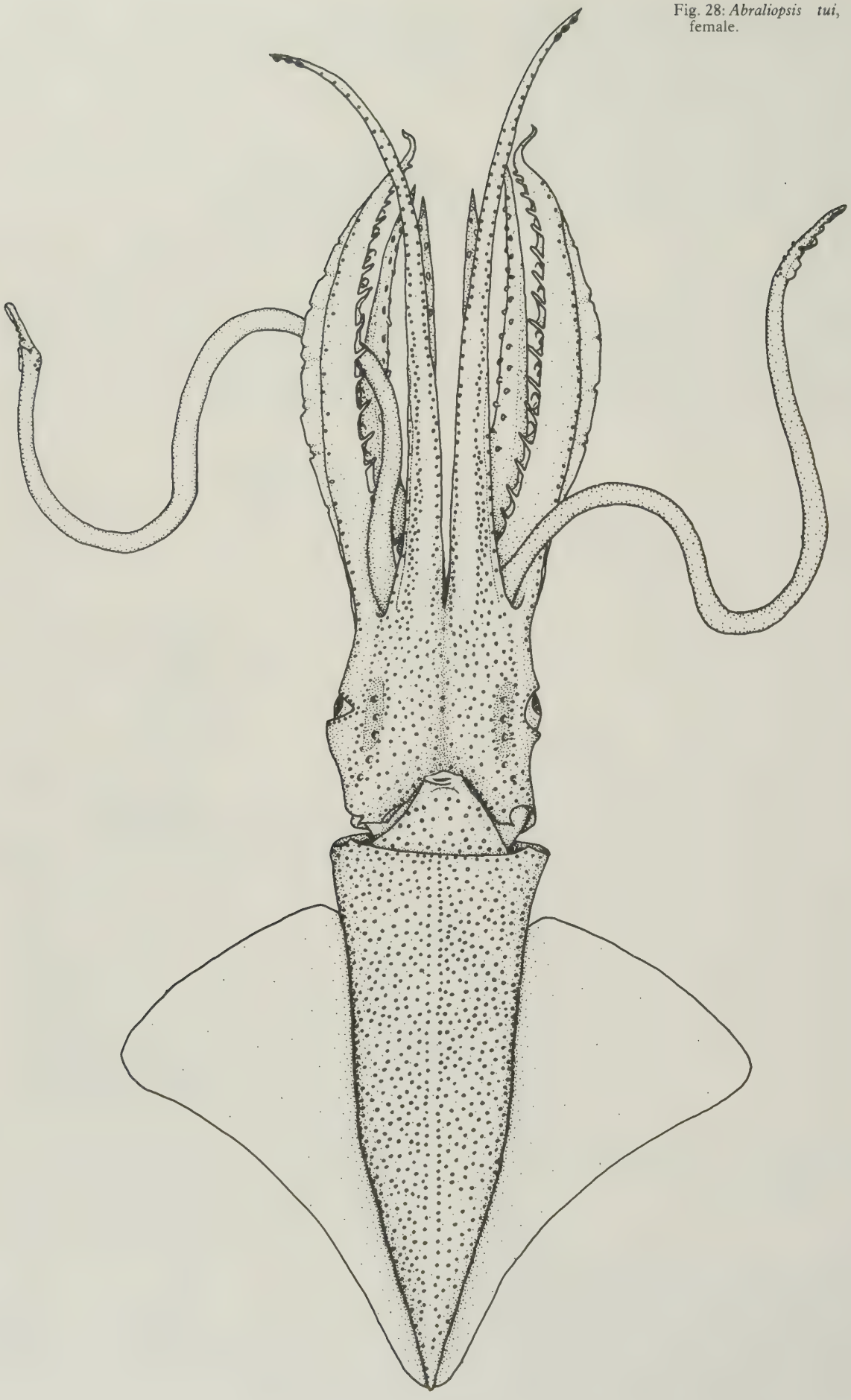


Fig. 28: *Abraliopsis tui*, ML 30.2 mm, female.

15.0 mm, 15.8 mm J17/22/76; 1 juvenile ML 14.5 mm J17/22/76; 1 juvenile ML 15.1 mm J12/37/75; 1 juvenile ML 16.0 mm J17/67/76; 2 females ML 24.1 mm, 23.6 mm J17/76/76; 1 male ML 29.4 mm J17/76/76.

Additional material: J9/34/76 ($n = 24$, mean ML = 26.2 mm, s.d. = 6.23); J9/41/76 ($n = 23$, mean ML = 26.6 mm, s.d. = 4.36); J9/43/76 ($n = 21$, mean ML = 19.5 mm, s.d. = 5.27); J9/67/76 ($n = 28$, mean ML = 23.7 mm, s.d. = 5.85); J17/30/79 ($n = 92$, mean ML = 16.9 mm, s.d. = 3.40); J17/39/76 ($n = 94$, mean ML = 20.7 mm, s.d. = 4.22); J17/58/76 ($n = 281$, mean ML = 17.0 mm, s.d. = 2.90); J17/60/76 ($n = 42$, mean ML = 17.7 mm, s.d. = 3.65); J17/65/76 ($n = 56$, mean ML = 15.1 mm, s.d. = 2.07); J17/68/76 ($n = 61$, mean ML = 12.9 mm, s.d. = 1.87); J17/77/76 ($n = 89$, mean ML = 23.8 mm, s.d. = 2.64); 237 specimens (mean ML 21.6 mm, s.d. = 5.87) distributed as follows: AUZ 088 01 (1); AUZ 108 11 (1); J9/10/76 (4); J9/12/76 (8); J9/13/76 (4); J9/15/76 (5); J9/16/76 (2); J9/17/76 (13); J9/19/76 (3); J9/21/76 (1); J9/23/76 (3); J9/29/76 (3); J9/36/76 (7); J9/43/76 (1); J9/45/76 (6); J9/49/76 (10); J9/54/76 (11); J9/56/76 (25); J9/58/76 (11); J9/60/76 (3); J9/62/76 (14); J9/68/76 (6); J17/10/76 (1); J17/12/76 (2); J17/19/76 (2); J17/21/76 (11); J17/22/76 (9); J17/28/76 (2); J17/29/76 (5); J17/29/76 (5); J17/32/76 (12); J17/38/76 (2); J17/47/76 (4); J17/48/76 (1); J17/57/76 (2); J17/64/76 (5); J17/67/76 (8); J17/70/76 (4); J17/73/76 (3); J17/76/76 (5); J17/79/76 (11); J17/85/76 (1).

Mantle. Moderately broad, anterior half near cylindrical, anterior margin flared, posterior half conical. Mantle tip bluntly rounded, non-muscular. Dark tip of gladius sometimes visible through ventral side of mantle. Dark line of gladius very distinct dorsally. Mantle margin produced dorsally in a shallow V. Small projections of mantle edge at locking cartilages.

Fins. Very large. Length index 73–79. Width index 101–111. Fins meeting posteriorly and extending a short way beyond mantle tip. Posterior margins strongly concave, tips bluntly rounded, anterior margins weakly convex, almost straight. Large, clearly defined, free anterior lobes.

Funnel. Short, muscular, triangular in outline. Locking cartilages straight, simple. Dorsal component of funnel organ with lateral pads broadest posteriorly. Prominent ridges along anterior two-thirds of each. A very short medial ridge at anterior tip of organ. Ventrolateral pads elongate, sides almost parallel.

Head. Rounded posteriorly, squarish anteriorly. Eyes very large, eye socket with distinct sinus anteriorly (Fig. 29a). Ventral nuchal fold, bearing "olfactory" papilla, arising at level of ventral eyelid. Two crests dorsad of this, lower crest curving posterodorsally to meet most dorsal crest, both together forming a C-shaped ridge.

Arms. Very long, order of length 4. 3 = 2. 1, ventral pair much the longest (ALI. IV = 100–110). Dorsal two pairs with low keel along anterior third of each arm, third arm with broad keel along whole length. Dorsal two pairs with low keel along whole length. Dorsal protective membranes absent. Ventral membranes well developed, trabeculate on all but ventral arms. Ventral arms with narrow lateral webs. Between 17 and 23 hooks, largest proximally, on each arm, those of ventral arms much smaller than those of other arms. About 30 minute suckers in 2 rows distally on arms I–III. Most proximal six of these larger, darker, with square-tipped teeth on distal edge of inner ring, others smaller, globose, with smooth rings and very small apertures.

Hectocotylus. On right ventral arm of male. Little modified, a fleshy, broad membrane running from level of tenth hook to level of fifteenth hook on ventral edge of oral surface (Fig. 29e). No membrane on dorsal edge.

Tentacles. Slender, not especially long, rectangular in cross section. Club not expanded. Five suckers in carpal cluster. Six to nine hooks on manus in two rows, usually eight in females, six or seven in males. Hooks of ventral row very large, slender, dorsal hooks small, broad based. Usually a minute sucker associated with the base of each dorsal hook. Dactylus short, bearing four rows of minute suckers, each row about ten suckers long. Aborally a keel extending from tip of dactylus to level of second pair of hooks. A membranous flap aborally running from level of carpal cluster to level of first or second pair of hooks (Fig. 29c).

Buccal membrane. Dark, purplish, short, with eight buccal lappets, connectives attached DDVD.

Photophores. Liberally scattered over ventral surface of mantle, but absent from a strip along the midventral line, save for a single row around anterior mantle margin. Photophores of two types present: large organs with white centres, smaller organs with dark grey centres. Both scattered, but an indefinite line of large organs running posteriorly from locking cartilages; this line very obvious in juveniles, separated from other ventral photophores by a clear band. A few scattered organs dorsad of this, including a few on dorsal surface anterior to fins. Two broad bands on funnel medially, separated by a clear space mid ventrally, about 25 organs in each in mature animals. Laterally a narrower pair of bands, about eight organs each. A few scattered organs dorsally. Ventral surface of head with widely scattered photophores of both types. Ventrolaterally an area devoid of photophores over ventral windows of eyes. Dorsad of this two ill-defined rows, merging with other photophores posteriorly, continuing along outer edge of ventral arm web anteriorly, the row becoming uniserial, sparse, reaching along two-thirds of arm's length. A series of about 50 unevenly sized organs around eyelid, most closely packed ventrally. On ventral arms, an irregular uniserial row extending along median edge for five-sixths of arm's length. A second series, at first

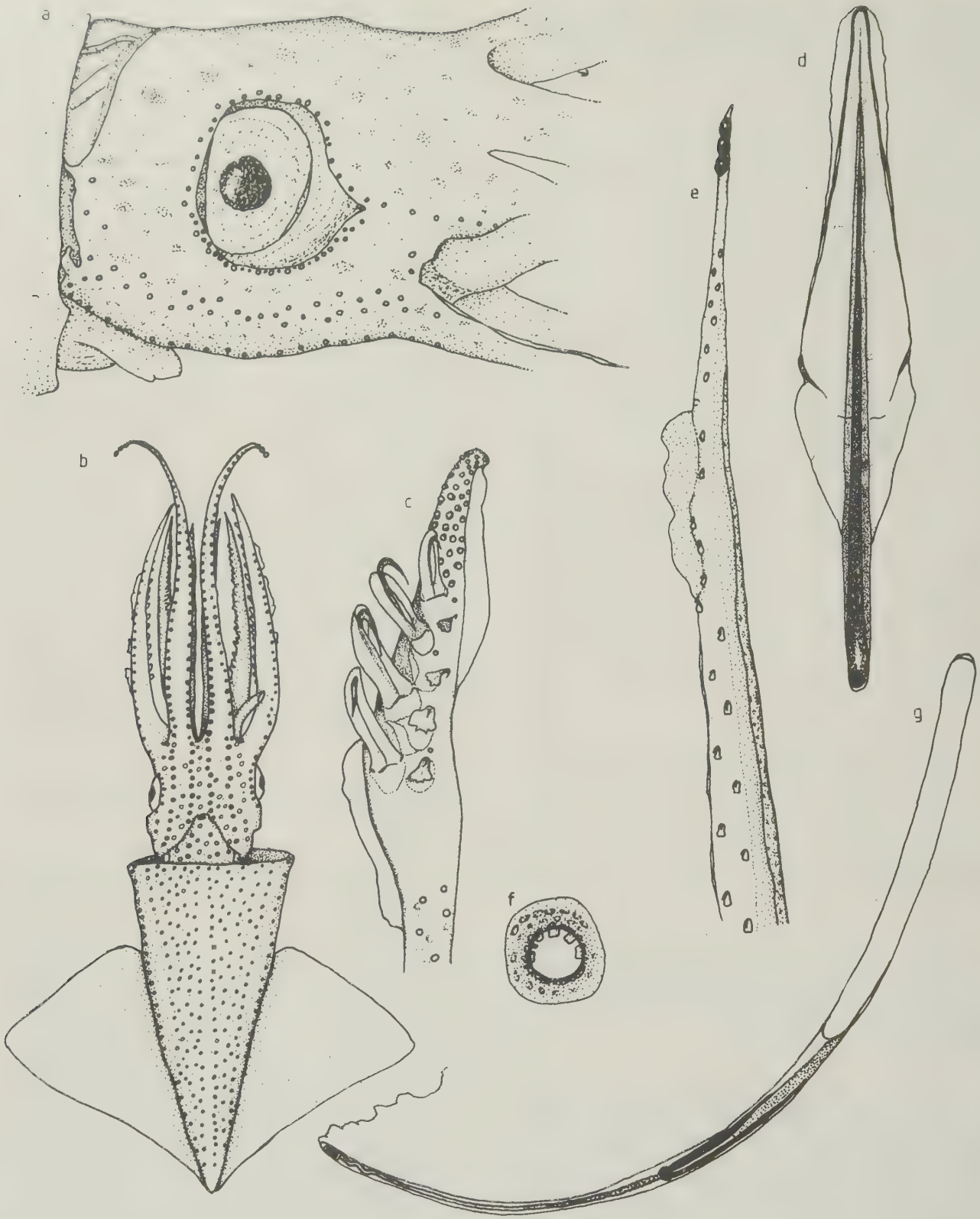


Fig. 29: *Abraliopsis tui*: a, head, lateral view, right side; b, juvenile, ML 16.0 mm; c, right tentacular club; d, gladius; e, hectocotylus; f, second distal sucker, arm II; g, spermatophore.

roughly biserial, becoming uniserial, extending along lateral edge of ventral arm to arm tip. Tip of ventral arm with three very large black spherical photophores. A uniserial row extending along base of keel on arm III on ventral side, reaching arm tip, arising just dorsad of sinus of eye socket from series around eye. Five large reddish photophores in a single row around ventral periphery of eyeball.

Colour. In preservative, ground colour light tan, overlaid by numerous small reddish brown chromatophores everywhere except fins, inner surfaces of arms and tentacles, posterior of funnel, and head. Photophores purplish.

Spermatophores. Length 10.2 mm. Sperm mass about 40% of total length, not reaching to aboral tip, cement gland spindle shaped, with distinct knob at anterior end, spiral filament highly sculptured as it leaves cement gland, becoming simple approaching oral tip, where it coils tightly (Fig. 29g).

Distribution

This species has the widest distribution throughout the New Zealand region of any enoploteuthid and is probably the commonest species in these waters. It occurs on both sides of the Tropical Convergence and, though it is perhaps more common to the north of this (up to 281 specimens have been taken in a single sample), it is still very common around the Kermadecs. South of about 32° S its abundance decreases, and only two specimens have been taken off the New Zealand mainland, one in the Bay of Plenty and one east of East Cape (Fig. 30). The species appears to prefer deep water, but it has been taken on the edge of the Kermadec Ridge at a bottom depth of 50–184 m.

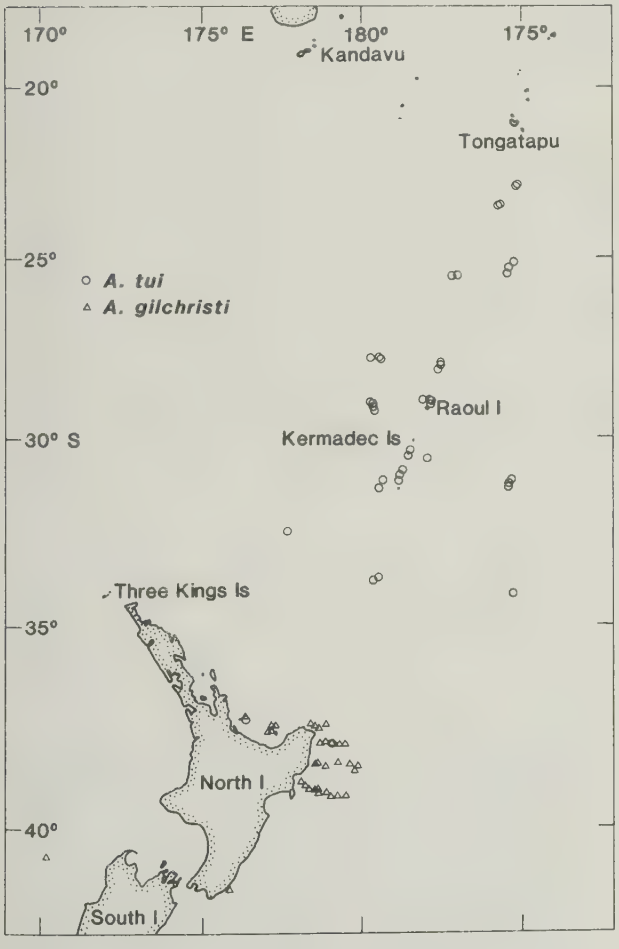


Fig. 30: Distribution of *Abraliopsis* spp.

Most specimens were taken at night from non-closing nets trawled at depths of between 45 and 93 m. They have been taken at depths as shallow as 20 m. One sample of 42 animals was taken from a net trawled at 377 m, though these could have been captured during the raising or lowering of the net.

Remarks

The subgenus *Abraliopsis (Abraliopsis)*, to which this species belongs, has three described species, all of similar appearance. The most recently described, *A. felis* McGowan and Okutani, is probably the most distinctive. It has no keel on the dactylus and no aboral flap on the carpus, and its body proportions are quite different from those of the present species (FLI = 62–68, FWI = 70–83, ALI. IV = 55–60). There is only a single series of photophores lateral to the ventral window of the eye, and the photophore row on the ventral surface of arm III does not reach the arm tip. There are also fewer hooks on the arms, particularly the ventral pair (10–15) (McGowan and Okutani 1968, Young 1972).

The present species is more similar to *A. pfefferi* Joubin, a species known from the Atlantic and eastern Indian Oceans (Voss 1967), but it differs from it in a few important respects. Firstly, there are 6–9 hooks on the clubs, rather than 10–12 (Joubin 1896, Young 1972). There is some degree of sexual dimorphism in this character, with males usually having six or seven hooks and females eight. There appear to be more hooks on the hectocotylus than in *A. pfefferi*, though this is not certain, as many of the hooks are missing from the arms of all five *A. pfefferi* specimens examined. Cairns (1976) presents an illustration of the hectocotylus of this species: his specimen had 14 hooks on this arm, the last one not distad of the distal end of the ventral flap. In *Abraliopsis tui* there are several hooks distad of this flap. In most males of *A. pfefferi* there is a small flap near the distal end of the ventral flap (Young (1972) describes a specimen in which this flap is absent), which is lacking in *Abraliopsis tui*. The reduction of hooks 7 and 8 described by Cairns is almost certainly not a valid character: often the arm hooks of these animals drop off after capture, leaving only the hoods. This is probably what happened to Cairns's specimen, as hooks 7 and 8 of the two males examined here were of normal development.

The fins of adult and subadult *Abraliopsis tui* are about the same width as those of *A. pfefferi* (FWI = 101–111 v. 102–110), but are rather longer (FLI = 73–77 v. 66–72). The ventral arms also seem to be rather longer (ALI. IV = 100–110 v. 94–101), but the poor condition of the *A. pfefferi* specimens makes this uncertain.

The mid-ventral line on the mantle of *Abraliopsis tui* is devoid of photophores, with the occasional exception of one or two organs at the anterior mantle margin. The *A. pfefferi* specimens have all been opened ventrally, which makes examination of the ventral midline difficult, but the clear mid-ventral strip

does not seem to extend as far anteriorly as the mantle margin, as described by Joubin (1896). Otherwise the photophore patterns of the two species are very similar.

The spermatophores of *Abraliopsis tui* are larger than those of *A. pfefferi* (10.5 v. 8 mm) with a proportionately longer sperm mass (41% of total length v. 25%) and a more rounded knob on the end of the cement gland.

The final species, *A. hoylei* Pfeffer (actually the first to be described), is problematical, as only one specimen has ever been positively assigned to it (Young 1972). Its relationships with other members of the genus have been discussed by McGowan and Okutani (1968) and Young (1972). The following characters seem to distinguish it from the present species.

1. The fin width index is only 95, rather than 101–111.
2. The ventral arms are only 75% of the mantle length, rather than 100–110%.
3. The first few distal suckers on the arms have pointed rather than square teeth.
4. The mid-ventral strip lacking photophores does not approach the anterior mantle margin.
5. There is a dorsolateral field of photophores on the mantle which is separated from the ventral field by a clear space. No distinct dorsolateral field occurs in *Abraliopsis tui*: the photophores merely become sparser dorsally.

The species is easily distinguished from the only other *Abraliopsis* known from the region, *A. gilchristi*, by the characters discussed in the next section. Only juveniles may cause problems with identification: the juveniles of this species first develop the photophores of the ventral surface of the head in four rows, as in *A. gilchristi*. However, the rows are never as distinct as in that species, and there are always additional photophores between all rows, rather than just between the middle pair as in *A. gilchristi*. In addition, the mantle photophores are in broad fields rather than distinct rows as in juveniles of *A. gilchristi* (Figs. 29b, 32d).

Berry (1914b, 1916) tentatively identified a badly damaged *Abraliopsis* specimen washed ashore on Raoul Island as *A. hoylei*. Since the present species is the only one in the genus known to occur around this island (where it is very common), it is more likely that this is the species to which Berry's specimen belongs.

***Abraliopsis gilchristi* (Robson, 1924)** (Fig. 31)

Abralia gilchristi Robson, 1924a p. 3; 1924b p. 601, pl. 1, figs. 6–7.
Enoploteuthis neozelanica Dell, 1959 pp. 6–8, figs. 11–13, p. 11.
Abraliopsis neozealandica Clarke, 1966 p. 178.
Abraliopsis neozelanica Roper, 1966 p. 44.
Abraliopsis gilchristi Voss, 1962 p. 264; 1967 pp. 66–70, pl. I, II.

Material examined: 11 males ML 18.0–25.5 mm J1/19/80; 8 males ML 20.7–25.3 mm J1/17/80; 7 males ML 23.9–34.5 mm J1/18/80; 5 males ML 26.0–34.8 mm J1/51/80; 3 males ML 26.9–34.2 mm J1/54/80; 3 males ML 23.0–33.3 mm J4/66/80; 3 males ML 32.4–35.9 mm J13/19/80; 3 males ML 26.0–30.5 mm J1/56/80; 3 males ML 17.2–18.5 mm J8/79/80; 2 males ML 32.5 mm, 33.5 mm J1/37/80; 2 males ML 28.2 mm, 30.9 mm J1/53/80; 2 males ML 24.5 mm, 30.3 mm J13/22/79; 2 males ML 20.5 mm, 21.5 mm J1/4/80; 1 male ML 40.2 mm J13/11/79; 1 male ML 35.8 mm J13/12/79; 1 male ML 35.4 mm J16/71/76; 1 male ML 33.3 mm J13/20/79; 1 male ML 31.5 mm J7/56/75; 1 male ML 31.1 mm J8/17/80; 1 male ML 30.5 mm J8/33/80; 1 male ML 29.8 mm J17/39/75; 1 male ML 27.2 mm J17/60/75; 1 male ML 25.4 mm J1/52/80; 1 male ML 25.1 mm J13/23/79; 1 male ML 22.2 mm J16/75/76; 1 male ML 19.0 mm J8/21/80; 1 male ML 18.0 mm J1/14/80; 20 females ML 20.0–40.2 mm J1/18/80; 12 females ML 16.8–37.0 mm J1/19/80; 8 females ML 21.5–40.3 mm J1/17/80; 5 females ML 22.4–37.7 mm J1/53/80; 5 females ML 17.7–35.5 mm J1/37/80; 4 females ML 26.1–37.2 mm J4/66/76; 3 females ML 18.0–30.6 mm J8/79/80; 2 females ML 45.1 mm, 49.2 mm J13/12/79; 2 females ML 38.2 mm, 38.7 mm J13/19/79; 2 females ML 29.0 mm, 42.9 mm J1/6/80; 2 females ML 29.4 mm, 36.8 mm J13/22/79; 2 females ML 30.5 mm, 36.1 mm J1/54/80; 2 females ML 24.2 mm, 24.6 mm J1/4/80; 1 female ML 43.4 mm J13/10/79; 1 female ML 42.8 mm J16/73/76; 1 female ML 41.3 mm J1/34/80; 1 female ML 38.1 mm J1/50/80; 1 female ML 35.2 mm J1/57/80; 1 female ML 35.2 mm J1/14/80; 1 female ML 34.5 mm J4/63/76; 1 female ML 33.8 mm J17/39/75; 1 female ML 27.5 mm J1/3/80; 1 female ML 27.5 mm J8/17/80; 1 female ML 26.5 mm J1/36/80; 1 female ML 26.4 mm J16/75/76; 1 female ML 25.0 mm J8/33/80; 1 female ML 23.9 mm J8/62/80; 1 female ML 22.5 mm J13/20/79; 1 female ML 19.6 mm J8/76/80; 3 juveniles ML 13.3–14.9 mm J17/57/75; 1 juvenile ML 10.6 mm J16/5/79; ? 2 juveniles ML 10.0 mm, 12.0 mm J17/89/76; 1 head J16/22/79. (There are several other specimens from some of the above samples which were in too poor a condition to sex or measure.)

This species, which is probably the most easily identifiable in the genus, has been thoroughly redescribed by Voss (1967). A description therefore need not be repeated here; the following characters should be sufficient to permit rapid identification of this species.

1. The characters of the genus (three enlarged terminal photophores on each ventral arm, large fins, two rows of hooks on the club) distinguish *A. gilchristi* from all other local species with the exception of the previous *Abraliopsis* species.

2. There are four rows of photophores on the ventral surface of the head, with a few scattered organs between the median rows, but none between each

median row and the row lateral to it. All other *Abraliopsis* species have either three rows in this position or a uniform photophore distribution as in the previous species. Species with distinct rows on the head are included in the subgenus *Micrabralia*; those with a uniform arrangement belong in the subgenus *Abraliopsis*.

3. From the other local *Abraliopsis* species it may also be distinguished by its proportionately longer and more slender mantle and shorter arms. The ventral arms of *A. gilchristi* are 75–91% of the mantle length.
4. *Abraliopsis gilchristi* tends to be rather paler than *A. tui*.
5. The juveniles of the two *Abraliopsis* species may be distinguished on the characters discussed in the previous section.

Distribution

The only previous records of this species in the literature are from South Africa (Robson 1924, Voss 1967) and New Zealand (Dell 1959), but *A. gilchristi* has been taken widely along the Antarctic Ocean from South Africa to South America and nearly across to New Zealand (Voss pers. comm.). It is probably present throughout the South Temperate Zone.

Unlike most enoploteuthids, it is occasionally found over the continental shelf in quite shallow water. Dell's specimen was taken from a commercial trawler working in 50 fathoms (91 m) (presumably bottom depth, as commercial trawlers do not operate in mid water at this depth around New Zealand), and other New Zealand material has come from bottom depths as shallow as 42 m (this specimen has possibly been mislabelled, but there are four other records from well within the 200-m line whose accuracy there is no reason to doubt). This presence inshore does not seem to be associated with spawning migrations as is the case with *Watasenia scintillans* (Sasaki 1929): ripe and spent adults are found both on and off the shelf, as are juveniles and subadults (Fig. 33). Most of the specimens have come from between East Cape and Mahia Peninsula (Fig. 30), probably reflecting at least in part a greater fishing effort in that area. Nonetheless, extensive cruises in the Bay of Plenty have taken relatively few specimens (11 in the Bay of Plenty compared with 186 from between East Cape and Mahia Peninsula—in the same areas, 11 and 0 *E. galaxias* were taken). None have come from further north, with the possible exception of two poorly preserved juveniles taken at 36° S, 175° W, which have been tentatively assigned to this species. So *A. gilchristi* seems to prefer cooler water. Other specimens have come from west of Farewell Spit and east of Wellington (Dell 1959).

Most of the New Zealand specimens have been taken at a depth of 30 m, presumably at night (information on time of sampling is not available for many sites). Several have come from the surface and moderate sized catches have been made as deep as 220 m. Specimens from nets fished deeper than this (320 and 386 m) are probably contaminants captured while raising or lowering the net.

Remarks

In 1959, Dell described a new species of enoploteuthid from a specimen taken from a commercial trawler which had been working in 50 fathoms (91 m) off Kahu Rocks on the east coast of the North Island near Wellington. He called it *Enoploteuthis neozelanica*. It was considered to be a juvenile specimen, because of the "shape and general proportions", and it was distinguished from juvenile specimens of other *Enoploteuthis* species by details of the club, by the "irregular" arrangement of photophores on the ventral surface of the mantle, and in having fewer photophores on the eyeball.

From the description, however, it is obvious that the specimen is fully mature (it has a mantle length of 37 mm and a fully developed hectocotylus) and belongs in *Abraliopsis*. Voss (*in* Roper 1966) considers it to be synonymous with *A. gilchristi*. This view is, in my opinion, correct. Specimens which agree closely with both Voss's and Dell's descriptions are of the enoploteuthid species most commonly collected around the New Zealand mainland, and the only one to be collected regularly over the continental shelf. A search through the cephalopod collections of the National (formerly Dominion) Museum for the type of *E. neozelanica* was unsuccessful, but it seems almost certain from Dell's description that it belongs to the same species as the rest of the New Zealand material considered here. However, the following differences from the present material may be noted.

1. There are "several" rows of minute distal suckers on the arms, rather than two as in the present material and all other known *Abraliopsis* species. This is probably an error, unless perhaps Dell meant that there are several transverse rows, each only two suckers long.
2. There are four photophores on the eyeball, rather than five. These photophores are easily damaged, however, and as all known *Abraliopsis* species have five organs it is most probable that Dell's specimen had suffered some damage.
3. The large, elongate photophore on the tip of each ventral arm of *E. neozelanica* would of course be a closely packed series of three spherical organs as in other *Abraliopsis* species.
4. Dell's illustration (fig. 11) of the ventral surface shows a scattering of ambiguous dots between the lateral and median photophore rows on the head, which could be construed to be photophores. There are no such organs in the present material, nor in specimens of *A. gilchristi* from South Africa, and as there is no mention of photophores in this position in the text, these dots are probably not intended to represent photophores.

None of these differences appears to be real, and so it may be concluded that *E. neozelanica* is conspecific with the material which is here referred to *A.*

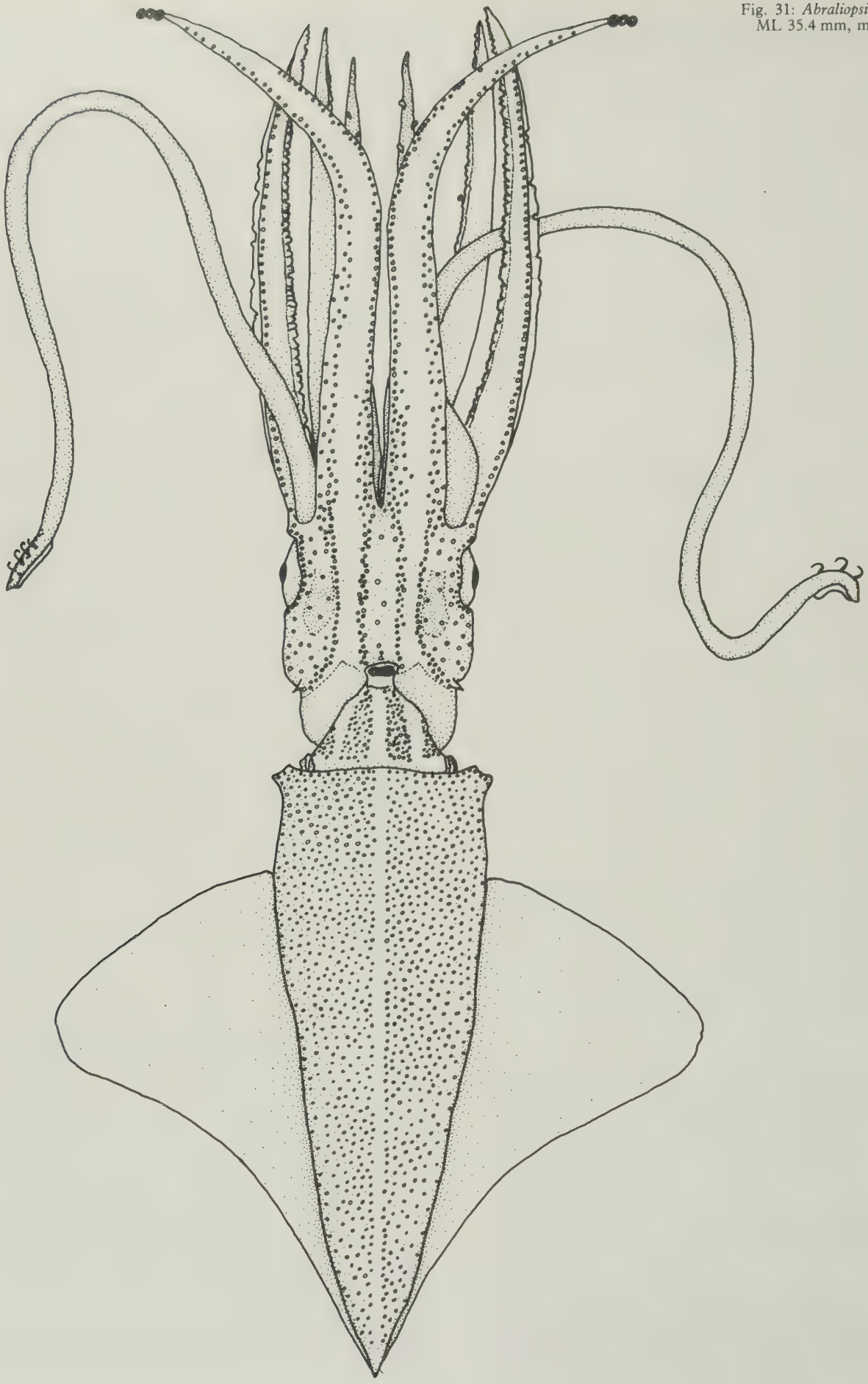


Fig. 31: *Abraliopsis gilchristi*, ML 35.4 mm, male.

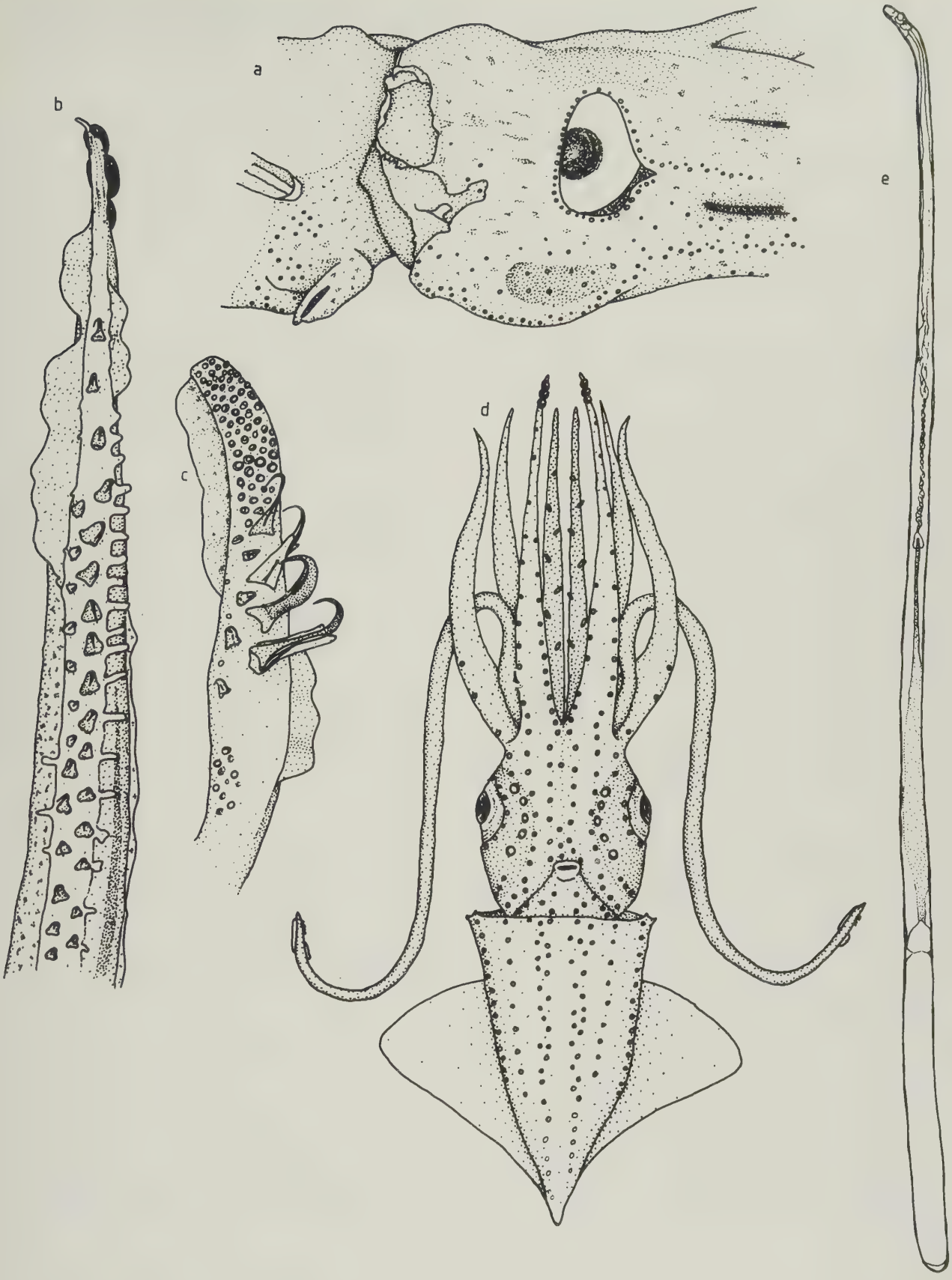


Fig. 32: *Abraliopsis gilchristi*: a, head, lateral view, right side; b, hectocotylus; c, left tentacular club; d, juvenile, ML 13.2 mm; e, spermatophore (length 22 mm).

gilchristi. Only one constant difference has been recognised between *A. gilchristi* from South Africa and New Zealand: the New Zealand specimens have a series of minute suckers associated with the dorsal hooks of the club (Fig. 32c) which Voss's (1967) South African specimens lack, a difference which, taken by itself, is not sufficient to justify recognising the New Zealand form as a distinct species.

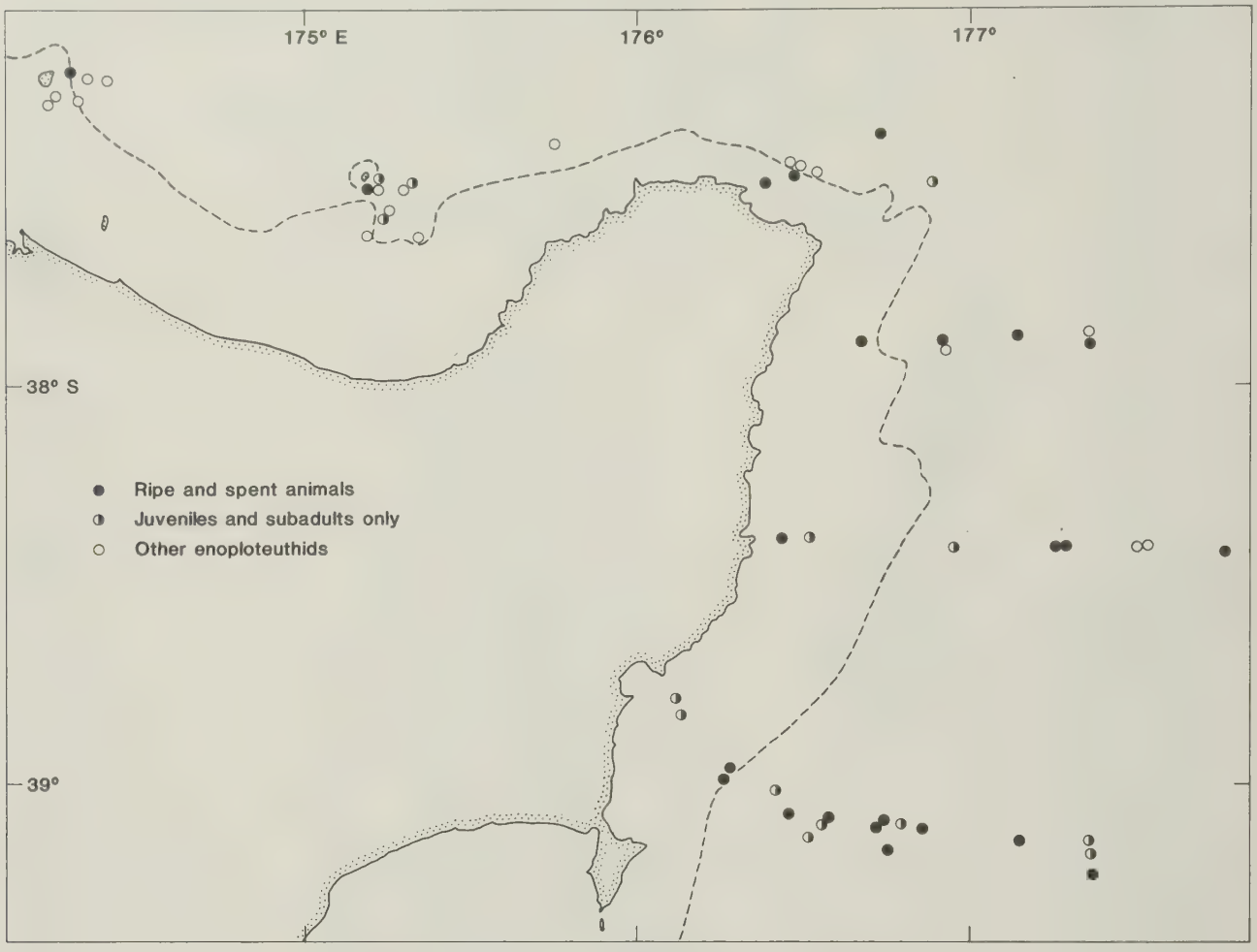


Fig. 33: Distribution of *Abraliopsis gilchristi* in East Cape region.

KEY TO THE NEW ZEALAND ENOPLOTEUTHIDAE

This key is designed to permit rapid identification of the species known to occur in the New Zealand region. No dissection is necessary to identify any of the characters used, and where possible more than one character is given in case one is obliterated through damage to the specimen. Attempts have been made to allow for developmental stages, but very small individuals (less than 10–12 mm ML) may still be difficult to identify with any certainty.

1. Photophores absent from epidermis of mantle and head. Fin length index less than 65. Posterior borders of fins convex ..... Pyroteuthinae 2

   Photophores present on epidermis of mantle and head. Fins with concave posterior borders (excluding some juvenile specimens) or with fin length index greater than 65 6

2. Hooks present on tentacular clubs and arms IV. Arm length index of ventral arms about 55. Transverse series of 3 photophores on viscera, between gills ... *Pyroteuthis* 3

   Hooks absent from tentacular clubs and arms IV. Arm length index of ventral arms about 40. Single photophore on viscera between gills ..... *Pterygioteuthis* 4

3. 4 large oval photophores on tentacles, with small photophore proximally and distally. Hectocotylus with a membranous flap, several suckers distally, and large proximal hooks with irregularly toothed primary cusps. 13–29 minute suckers distally on ventral arms ..... *Pyroteuthis serrata*

   3 large oval photophores and 3 small photophores on tentacles. Hectocotylus with a fleshy pad, 0–2 suckers distally, proximal hooks untoothed, with large rounded secondary cusp. 0–13 minute suckers distally on ventral arms ..... *Pyroteuthis margaritifera*

4. Suckers absent from ventral arms. Hooks in both rows on other arms. Hectocotylus with pocket containing bidentate plate ..... *Pterygioteuthis giardi*

   Suckers present on ventral arms. Hooks in ventral row only on other arms. Hectocotylus plate with many teeth 5

5. Males with a total of 6–12 hooks on lateral arms. Hectocotylus plate with dark teeth. Females becoming ripe at 18 mm ML, not growing larger than 23 mm ML ..... *Pterygioteuthis microlampas*

   Males with a total of 13–20 hooks on lateral arms. Hectocotylus plate wholly transparent. Females becoming ripe at 26 mm, growing to 32 mm ML ... *Pterygioteuthis gemmata*

6. Fins very large, posterior borders not noticeably concave. Superficial bead-like photophores present on mantle, head, and tentacles. Photophores absent from eyeball ..... *Ancistrocheirus* sp.

   Fins small to large, posterior borders concave (unless juvenile). Photophores of mantle, head, and arms minute, embedded in epidermis, absent from tentacles. Photophores present on eyeball ..... *Enoploteuthinae* 7

7. Fins subterminal on adults and subadults, with semi-gelatinous tail present. 2 rows of hooks on tentacular clubs. Suckers present on hectocotylus. 9 (8–10) photophores on eyeball. Photophores absent from dorsal eyelid ..... *Enoploteuthis* 8

   Fins terminal. 1 or 2 rows of hooks on clubs. Suckers usually absent from hectocotylus. 5 (possibly more) photophores on eyeball. Photophores present on dorsal eyelid 10

8. Mantle photophores in 6 uniserial or biserial rows, with patches of photophores between rows forming cross-linked pattern (adults), or arranged in discrete patches with longitudinal lines poorly developed or absent (juveniles). Tentacles very slender, 2 rows of suckers on dactylus, no aboral flap on carpus ..... *Enoploteuthis reticulata*

   Mantle photophores otherwise. Tentacles well developed, 4 rows of suckers on dactylus, aboral flap present on carpus 9

9. 3 triserial rows of photophores on ventral surface of head. Mantle photophores with regularly arranged clear patches (adults and subadults) or in 4 longitudinal lines (juveniles) ..... *Enoploteuthis galaxias*

   Mantle photophores in longitudinal rows, at all stages of development (?). Median row of photophores on ventral surface of head lacking ..... *Enoploteuthis ?jonesi*

10. Fins greater than 60% of mantle length (excluding juveniles). 2 rows of hooks on club. 3 (2–4) enlarged photophores on tips of each ventral arm ..... *Abraliopsis* .. 11

    Fins usually less than 60% of mantle length. 1 row of hooks on club. Photophores on tips of ventral arms absent or not enlarged ..... *Abralia* .. 12

11. 4 prominent rows of photophores on ventral surface of head; no photophores between any but middle pair of rows. Juveniles with mantle photophores in 4–6 discrete rows ..... *Abraliopsis gilchristi*

    Photophores uniformly distributed over ventral surface of head, developing initially in 4 rows in juveniles, but with a few photophores between all rows. Mantle photophores of juveniles in broad bands ..... *Abraliopsis tui*

12. Club with 2 hooks, aboral keel running from tip of dactylus to second hook. Mantle short and broad. Arms short. Photophores of mantle not arranged in rows. Right arm of male hectocotylised. 5 photophores on eyeball ..... *Abralia* n.sp.

    Club with 4 hooks, aboral keel running from tip of dactylus to second hook. Juveniles with very short, broad mantle. Arms about as long as mantle. Photophores not obviously arranged in rows ..... *Abralia* sp. B

    Club with 4 or 5 hooks. Aboral keel running from tip of dactylus to third hook. Mantle slender. Arms of moderate length. Photophores arranged in 6 rows on mantle. 3 triserial photophore rows on head. 3 minute, darkly pigmented photophores (relatively large, and unpigmented, in juveniles) at tips of ventral arms. Right arm of male hectocotylised. 5 photophores on eyeball *Abralia astrolineata*

FEEDING

The stomachs of a number of specimens were opened and the contents examined. Many of the stomachs were completely empty, and the material present in the others was invariably finely macerated. In most cases it was impossible even to determine how many prey items were present. No attempt has been made to quantify the relative abundances of prey items in the diet, therefore, but the following observations were made.

1. The stomachs of the smaller species contained many fragments of crustacean limbs. Most of these could not be identified, but the thoracic epipodites of *Nyctiphanes australis*, a euphausiid commonly present in the same samples as the squids, were a frequent item, as were small dark photophores, which may have come from the same species. A small decapod chela was found in the stomach of one *P. gemmata*.
2. One *E. galaxias* was found to contain fish vertebrae and other bones as well as the usual crustacean fragments.
3. Fragments of squid beaks, radulae, and eye lenses were found in the stomachs of *A. astrolineata*, *E. reticulata*, and *E. galaxias*, though not commonly.

Enoploteuthids, particularly when small, therefore seem to feed predominantly, if not almost exclusively, on small to medium sized pelagic Crustacea, particularly krill and small prawns. Larger individuals may also take fish (probably myctophids) and smaller squid.

ACKNOWLEDGMENTS

Of the many people who have assisted with this study, I particularly thank the following: Professor M. C. Miller, for supervising the study and providing much invaluable assistance, advice, and criticism; Mr Peter Roberts, for his help in getting started, for accommodation in Wellington, and for arranging finance for transport and boat trips; Dr Rob Mattlin, for help and advice; the crews of the research vessels *James Cook* and *Ikatere* and technical staff of Fisheries Research Division for assistance with field work and with the sorting of specimens; Drs L. A. Burgess, C. C. Lu, C. F. E. Roper, G. L. Voss, N. A. Voss, and R. E. Young for providing information, literature, and comparative material, without which this study would not have been possible; and Dr S. W. Taylor and Annette Taylor for word processing facilities.

REFERENCES

ADAM, W. 1954: Céphalopoda. 4. Céphalopodes à l'exclusion des genres *Sepia*, *Sepiella* et *Sepioteuthis*. *Siboga Expeditie 55c*: 121–98.

ARNOLD, J. M., and YOUNG, R. E. 1974: Ultrastructure of a cephalopod photophore. I. Structure of the photogenic tissue. *Biological Bulletin, Marine Biological Laboratory 147*: 507–21.

ARNOLD, J. M., YOUNG, R. E., and KING, M. V. 1974: Ultrastructure of a cephalopod photophore. II. Iridophores as reflectors and transmitters. *Biological Bulletin, Marine Biological Laboratory 147*: 522–34.

BERRY, S. S. 1913: Some new Hawaiian cephalopods. *Proceedings of the U.S. National Museum 45 (1966)*: 563–6.

——— 1914a: The Cephalopoda of the Hawaiian Islands. *Bulletin of the U.S. Bureau of Fisheries 32*: 255–362, 11 plates.

——— 1914b: Notes on a collection of cephalopods from the Kermadec Islands. *Transactions and Proceedings of the New Zealand Institute 46*: 134–49.

——— 1916: Cephalopoda of the Kermadec Islands. *Proceedings of the Academy of Natural Sciences of Philadelphia 68*: 45–66.

——— 1918: Report on the Cephalopoda obtained by the F.I.S. "Endeavour" in the Great Australian Bight and other southern Australian localities. *Biological Results of the Fishing Experiments carried on by the F.I.S. "Endeavour", 1909–14, 4 (5)*: 203–98, plates LIX–LXXXVIII.

BURGESS, L. A. 1982: Four new species of squid (Oegopsida: *Enoploteuthis*) from the central Pacific and a description of adult *Enoploteuthis reticulata*. *Fishery Bulletin 80 (4)*: 703–34.

CAIRNS, S. D. 1976: Biological results of the University of Miami deep-sea expeditions. 118. Cephalopods collected in the Straits of Florida by the R/V Gerda. *Bulletin of Marine Science 26*: 233–72.

CHUN, C. 1908: Ueber Cephalopoden der deutschen Tiefsee-Expedition. *Zoologischer Anzeiger 33*: 86–9.

CLARKE, M. R. 1966: A review of the systematics and ecology of oceanic squids. *Advances in Marine Biology 4*: 91–300.

——— 1969: Cephalopoda collected on the Sond cruise. *Journal of the Marine Biological Association of the U.K. 49*: 961–76.

——— 1977: Beaks, nets and numbers. *Symposium of the Zoological Society of London 38*: 89–126.

CLARKE, M. R., DENTON, E. J., and GILPIN-BROWN, J. B. 1979: On the use of ammonium for buoyancy in squids. *Journal of the Marine Biological Association of the U.K. 59*: 259–76.

CLARKE, M. R., and LU, C. C. 1974: Vertical distribution of cephalopods at 30°N 23°W in the North Atlantic. *Journal of the Marine Biological Association of the U.K. 54*: 969–84.

COTTON, B. C. 1942: Cephalopoda from stomach contents of fish from east and south Australia. *Transactions of the Royal Society of South Australia 66*: 83–4.

DELL, R. K. 1959: Some additional New Zealand cephalopods from Cook Strait. *Zoology Publications from Victoria University of Wellington, No. 25*. 12 p.

HEATH, R. A. 1973: Present knowledge of the oceanic circulation and hydrology around New Zealand—1971. *Tuatara 20 (3)*: 125–40.

HOYLE, W. E. 1886: Report on the Cephalopoda collected by HMS *Challenger* during the years 1873–76. *Report of the Voyage of the Challenger, Zoology 16 (44)*: 1–246.

——— 1906: The Cephalopoda. *In* "The Fauna and Geography of the Maldive and Laccadive Archipelagoes, 2." Cambridge University Press, Cambridge.

IMBER, M. J. 1973: The food of grey-faced petrels (*Pterodroma macroptera gouldi* (Hutton)), with special reference to diurnal vertical migration of their prey. *Journal of Animal Ecology 42*: 645–62.

——— 1975: Lycoteuthid squids as prey of petrels in New Zealand seas. *N.Z. Journal of Marine and Freshwater Research 9*: 483–92.

——— 1976: Comparison of prey of the black *Procellaria* petrels of New Zealand. *N.Z. Journal of Marine and Freshwater Research 10*: 119–30.

JOUBIN, L. 1896: Observations sur divers céphalopodes. 1. *Abraliopsis pfefferi* (nov. gen. et spec.). *Bulletin de la Société scientifique et médicale de l'Ouest 5*: 19–35.

——— 1900: Céphalopodes provenant des campagnes de la Princesse-Alice (1891–1897). *Résultats des campagnes scientifiques accompliés par le Albert I 17*: 1–135.

LU, C. C., and ROPER, C. F. E. 1979: Cephalopods from deepwater dumpsite 106 (Western Atlantic): vertical distribution and seasonal abundance. *Smithsonian Contributions to Zoology 288*. 36 p.

MCGOWAN, J. A., and OKUTANI, T. 1968: A new species of enoploteuthid squid, *Abraliopsis (Watasenia) felis*, from the California Current. *The Veliger 11 (1)*: 72–9.

MASSY, A. L. 1916: Mollusca. 2. Cephalopoda. *British Antarctic ("Terra Nova") Expedition, 1910. Zoology 2*: 141–76.

MORALES, E., and GUERRA, A. 1977: Teuthoidea: Oegopsida (Mollusca, Cephalopoda) from the North-west African coast. *Investigacion Pesquera 41 (2)*: 298–322.

NESIS, K. N. 1978: The subfamily Ancistrocheirinae (Cephalopoda, Enoploteuthidae). *Zoologicheskii Zhurnal 57 (3)*: 446–50. [Russian, with English abstract: translated by S. Surus, Department of Russian, University of Auckland.]

OKUTANI, T. 1976: Rare and interesting squid from Japan—5. A gravid female of *Ancistrocheirus lesueuri* (d'Orbigny, 1839) collected in the Kuroshio area (Oegopsida: Enoploteuthidae). *Venus, Tokyo 35 (2)*: 73–81.

OKUTANI, T., and HASEGAWA, M. 1979: A note on decapod cephalopods (squids) trawled from the southern eastern Atlantic during May, 1977, through March, 1978. *Bulletin of the Tokai Kinki National Agricultural Experiment Station* [?]*0 (99)*: 9–22.

PFEFFER, G. 1912: Die Cephalopoden der Plankton-Expedition. *Ergebnisse der Plankton-Expedition der Humboldt-Stiftung 2*: i–xxi, 1–815, 48 plates.

RANCUREL, P. 1970: Les contenus stomacaux d'*Alepisaurus ferox* dans le Sud-Ouest Pacifique (Céphalopodes). *Cahiers O.R.S.T.O.M. Série Océanographie 8 (4)*: 3–87.

RIDGWAY, N. M., and HEATH, R. A. 1975: Hydrology of the Kermadec Islands region. *New Zealand Oceanographic Institute Memoir, No. 73*. 28 p.

ROBERTSON, D. A., ROBERTS, P. E., and WILSON, J. B. 1978: Mesopelagic faunal transition across the Subtropical Convergence east of New Zealand. *N.Z. Journal of Marine and Freshwater Research 12*: 295–312.

ROBSON, G. C. 1924: On the Cephalopoda obtained in South African waters by Dr J. D. F. Gilchrist in 1920–21. *Proceedings of the Zoological Society of London 1924 (39)*: 589–686.

ROPER, C. F. E. 1966: A study of the genus *Enoploteuthis* (Cephalopoda: Oegopsida) in the Atlantic Ocean with a redescription of the type species, *E. leptura* (Leach, 1817). *Dana Report No. 66*. 46 p.

——— 1973: Vertical and seasonal distribution of pelagic cephalopods in the Mediterranean Sea. Preliminary report. *Bulletin of the American Malacological Union 39*: 27–30.

ROPER, C. F. E., and YOUNG, R. E. 1975: Vertical distribution of pelagic cephalopods. *Smithsonian Contributions to Zoology, No. 209*. 51 p.

ROPER, C. F. E., YOUNG, R. E., and VOSS, G. L. 1969: An illustrated key to the families of the order Teuthoidea (Cephalopoda). *Smithsonian Contributions to Zoology, No. 13*. 32 p.

SASAKI, M. 1929: A monograph of the dibranchiate cephalopods of the Japanese and adjacent waters. *Journal of the College of Agriculture, Hokkaido Imperial University, 20 (supplementary number)*: 1–357.

VOSS, G. L. 1962: A monograph of the Cephalopoda of the North Atlantic. I. The family Lycoteuthidae. *Bulletin of Marine Science of the Gulf and Caribbean 12*: 264–305.

——— 1963: Cephalopods of the Philippine Islands. *Bulletin of the U.S. National Museum 234*: 1–180.

——— 1967: Some bathypelagic cephalopods from South African waters. *Annals of the South African Museum 50 (5)*: 61–88.

——— 1971: Cephalopods collected by the R/V John Elliott Pillsbury in the Gulf of Panama in 1967. *Bulletin of Marine Science 21*: 1–34.

——— 1973: Cephalopod resources of the world. *Food and Agriculture Organization of the United Nations Circular No. 149*. 75 p.

YOUNG, R. E. 1972: The systematics and areal distribution of pelagic cephalopods from the seas off southern California. *Smithsonian Contributions to Zoology, No. 97*. 159 p.

——— 1977: Ventral bioluminescent countershading in midwater cephalopods. *Symposium of the Zoological Society of London 38*: 161–90.

YOUNG, R. E., ROPER, C. F. E., MANGOLD, K., LEISMAN, G., and HOCHBERG, F. G., JNR. 1979: Luminescence from non-bioluminescent tissues in oceanic cephalopods. *Marine Biology 53*: 69–77.

APPENDIX 1

Sample information (samples arranged chronologically).

Sample No.	Date	Location		Net depth (m)	Bottom depth (m)	Time
AUZ 002 08	4/7/62	34°24′S	175°17′E	c.400		1340–1521
AUZ 008 11	5/7/62	32°30′S	174°14.5′E	50	3000–4000	2037–2116
AUZ 045 05	13/7/62	30°56.5′S	179°40′E	80	3000–4000	2026–2110
AUZ 067 18	22/7/62	35°13′S	176°16′E	800–900	1350	0107–0500
AUZ 068 03	22/7/62	35°15′S	176°15′E	600–650	1060–1170	0538–0825
AUZ 080 04	23/7/62	33°08′S	176°07′E	c.100	1980–4000	1631–2115
AUZ 086 02	24/7/62	31°57′S	177°38′E	350–500	4200	1555–1950
AUZ 088 01	24/7/62	32°05′S	177°31′E	c.100	3400–4000	1828–1918
AUZ 091 02	25/7/62	31°22′S	179°08′E	510		0505–0858
AUZ 097 05	25/7/62	31°19′S	179°20′E	350		2011–2125
AUZ 108 11	29/7/62	30°34′S	177°30′W	900	3400–4094	0215–0705
AUZ 115 06	30/7/62	30°55′S	178°17′E	c.550	2000–2200	2100–0101
AUZ 121 01	2/8/62	32°58′S	178°26′E	170	1600–1900	0415–0508
J7/23/75	6/5/75	37°18.2′S	176°18.1′E	118		
J7/24/75	6/5/75	37°17.3′S	176°18′E	91		
J7/39/75	8/5/75	37°31.01′S	177°12.9′E	110	172–200	
J7/56/75	9/5/75	37°28.3′S	177°13′E	80–386	194–994	
J12/37/75	15/8/75	37°18′S	176°22.12′E	421–549		
J12/39/75	15/8/75	37°15.48′S	176°26.12′E	614–747		
J12/41/75	15/8/75	37°32.38′S	177°17.36′E	227	1067–1142	
J12/56/76	16/8/75	37°27.36′S	178°26.18′E	277	1080–1460	
J12/58/75	16/8/75	37°29′S	178°27.54′E		1180	
J17/39/75	13/12/75	37°15′S	176°19.7′E	218–225	250–520	0303–0403
J17/42/75	13/12/75	37°14′S	176°26.5′E	305	633–660	0449–0549
J17/51/75	13/12/75	37°34.2′S	177°14.5′E	108	622–820	2332–0032
J17/54/75	13/12/75	37°34.2′S	177°14.5′E	108	622–820	2332–0032
J17/57/75	14/12/75	37°31.6′S	177°08.4′E		?160	0150–0250
J17/60/75	14/12/75	37°30.8′S	177°17.6′E	306–320	1298–1372	
J2/31/76	20/1/76	40°45′S	170°16.2′E			
J4/51/76	6/3/76	37°38.4′S	177°19.5′E			
J4/54/76	7/3/76	34°34′S	177°15.3′E	305	520	
J4/63/76	7/3/76	37°28.4′S	178°17.2′E	67–108	450–800+	
J4/66/76	7/3/76	37°28.4′S	178°29.4′E		220	
J9/10/76	14/6/76	30°59′S	178°41′W		792–1048	2102–2202
J9/12/76	14/6/76	30°55.2′S	178°37.3′W	215–225	1108–1196	2242–2342
J9/13/76	15/6/76	no information				
J9/15/76	15/6/76	30°47.2′S	178°31′W	25	1115	0210–0310
J9/16/76	16/6/76	29°14.62′S	177°50.04′W	14–20	220–960	1833–1933
J09/17/76	16/6/76	29°15.55′S	177°50.25′W	c.90	50–184	2022–2043
J9/19/76	16/6/76	29°15.7′S	177°51.8′W	18	40–944	2151–2251
J9/21/76	16/6/76	29°10.3′S	177°57.7′W	c.300	616–890	2332–0032
J9/23/76	17/6/76	29°10.8′S	177°57.6′W	51	51–3001	0112–0212
J9/29/76	17/6/76	no information				
J9/32/76	17/6/76	28°44.6′S	177°47′W	162	276–368	2136–2236
J9/34/76	17/6/76	28°40.4′S	177°45.2′W	c.80	232–572	2304–0004
J9/36/76	18/6/76	28°38.1′S	177°42.2′W	45	720–840	0032–0132
J9/41/76	18/6/76	27°50.7′S	178°40′W	73	1700	1849–1949
J9/43/76	18/6/76	27°50.8′S	178°45.5′W	45	1700	2023–2123
J9/45/76	18/6/76	27°50.8′S	178°50.2′W	c.20	1700	2149–2249
J9/47/76	18/6/76	27°50.8′S	178°55.5′W	c.400	1700	2330–0030
J9/49/76	19/6/76	27°50.8′S	179°0′W	45	1700	0106–0206
J9/54/76	19/6/76	28°35.2′S	179°27.6′E	84	1700	1900–2000
J9/56/76	19/6/76	28°39.5′S	179°25.6′E	45	1700	2038–2138
J9/58/76	19/6/76	28°42.2′S	179°23′E	c.20	1700	2200–2300
J9/60/76	19/6/76	28°45.6′S	179°20′E	c.30	1700	2331–0031
J9/62/76	20/6/76	28°48.1′S	179°17.1′E	48	1700	0105–0205
J9/67/76	20/6/76	30°54.01′S	179°11.95′E	89	1700	1849–1949
J9/68/76	20/6/76	30°54.5′S	179°07.4′E	c.30	1700	2010–2110
J11/87/76	2/8/76	37°37′S	177°12′E	190	406	2257
J11/99/76	3/8/76	37°28.7′S	178°34.7′E	174	1320	2300
J16/71/76	19/11/76	37°34.75′S	178°22.25′E	0*	42	
J16/73/76	20/11/76	37°21.7′S	178°45.6′E	0*	1380	
J16/75/76	20/11/76	37°31′S	178°52.5′E	0*	1080	
J17/6/76	4/12/76	35°00′S	179°29′W	338	3000+	0150–0250
J17/7/76	4/12/76	34°55′S	179°26′W	101	3000+	0335–0435
J17/9/76	4/12/76	33°15′S	179°13′W	695	3000+	1842–1942
J17/10/76	4/12/76	33°11′S	179°13′W	77	3000+	2045–2155
J17/12/76	4/12/76	33°05.8′S	179°13′W	433	3000+	2240–2340
J17/19/76	5/12/76	30°32′S	178°23′W	971	1100	1855–1955
J17/21/76	5/12/76	30°31′S	178°21′W	77	1620	2050–2150
J17/22/76	5/12/76	30°28.2′S	178°20′W	434	1600	2225–2325
J17/28/76	6/12/76	no information				
J17/29/76	6/12/76	28°08′S	177°23′W	774	1000+	1848–1948
J17/30/76	6/12/76	28°09′S	177°20′W	93		2038–2138
J17/32/76	6/12/76	28°08′S	177°22.5′W	397		2213–2313
J17/38/76	7/12/76	25°47.9′S	176°40.4′W	755	1280	1845–1945
J17/39/76	7/12/76	25°48′S	176°38′W	83		2032–2132
J17/47/76	8/12/76	23°00′S	175°31′W	348	1000+	1833–1933

Appendix 1—*continued*

Sample No.	Date	Location		Net depth (m)	Bottom depth (m)	Time
J17/48/76	8/12/76	23°06′S	175°29′W	53		2007–2107
J17/57/76	12/12/76	22°41.5′S	175°02′W	944	3000+	1845–1945
J17/58/76	12/12/76	22°46′S	175°02′W	59	3000+	2100–2200
J17/60/76	12/12/76	22°49′S	175°02′W	377	3000+	2235–2335
J17/64/76	13/12/76	25°20′S	175°08.5′W	613	7000+	1824–1924
J17/65/76	13/12/76	25°25′S	175°09′W	48	7000+	2020–2120
J17/67/76	13/12/76	25°29′S	175°09′W	327	7000+	2152–2252
J17/68/76	13/12/76		no information		5000+	
J17/70/76	14/12/76	28°13.2′S	174°56′W	1064	5000+	1832–1932
J17/71/76	14/12/76	28°18′S	174°56′W	94	5000+	2025–2125
J17/73/76	14/12/76	28°22′S	174°56′W	387	5000+	2151–2251
J17/76/76	15/12/76	30°58′S	175°12.8′W	971	5000+	1834–1934
J17/77/76	15/12/76	31°03′S	175°11′W	70	5000+	2041–2141
J17/79/76	15/12/76	31°08′S	175°11′W	377	5000+	2211–2311
J17/85/76	16/12/76	33°50.5′S	175°04.7′W	277	5000+	2226–2326
J17/89/76	17/12/76	36°03.4′S	175°16′W	46	5000+	2050–2220
JBC	5/7/77		North Cape	100		night
J18/33/78	18/11/78	34°20′S	173°16.8′E	30		
J13/4/79	30/9/79	37°50.86′S	178°55.4′E	30		
J13/10/79	1/10/79	38°22.16′S	179°15.69′E	30		
J13/11/79	1/10/79	38°22′S	179°35.35′E	30		
J13/12/79	1/10/79	38°22′S	179°45′E	30		
J13/19/79	1/10/79	39°09.15′S	178°49.65′E	30		
J13/20/79	1/10/79	39°05.43′S	178°38.9′E	30		
J13/22/79	2/10/79	38°57.8′S	178°16.55′E	30		
J13/23/79	2/10/79	38°50.07′S	178°08.93′E	30		
J15/4/79	4/11/79	37°23.88′S	177°41.98′E	30		
J15/39/79	7/11/79	34°56.7′S	175°17.13′E	30		
J16/5/79	19/11/79	39°05.23′S	178°38.04′E	30		
J16/22/79	19/11/79	39°05.23′S	178°38.04′E	30		
J1/3/80	10/1/80	38°57.7′S	178°16.3′E	29		
J1/4/80	10/1/80	39°01.7′S	178°28.2′E	0		
J1/6/80	10/1/80	39°04.38′S	178°31.64′E	100		
J1/14/80	10/1/80	37°51.56′S	178°29.78′E	30		
J1/17/80	11/1/80	37°51.6′S	178°54.7′E	30		
J1/18/80	11/1/80	37°50.9′S	179°08.1′E	30		
J1/19/80	11/1/80	37°51.6′S	179°19.83′E	30		
J1/34/80	11/1/80	38°22.12′S	178°25.63′E	30		
J1/36/80	12/1/80	38°22.4′S	178°57.1′E	22		
J1/37/80	12/1/80	38°22.1′S	179°15.9′E	30		
J1/50/80	12/1/80	39°07.25′S	178°49.08′E	0		
J1/51/80	12/1/80	39°06.65′S	178°50.18′E	30		
J1/52/80	12/1/80	39°06.48′S	178°53.16′E	100		
J1/53/80	13/1/80	39°07.7′S	178°57.2′E	200		
J1/54/80	13/1/80	39°09.8′S	179°08.9′E	30		
J1/56/80	13/1/80	39°09.5′S	179°22′E	0		
J1/57/80	13/1/80	39°11.12′S	179°22.15′E	30		
J7/59/80	12/4/80	39°02.27′S	172°13.5′E	530		
J8/17/80	20/4/80	38°22′S	178°26′E	30		
J8/21/80	21/4/80	38°22′S	179°37′E	30		
J8/33/80	22/4/80	38°49.3′S	178°07.4′E	30		
J8/45/80	23/4/80	39°09.5′S	179°22.5′E	30	1200+	0003–0033
J8/62/80	23/4/80	39°06.8′S	178°36.2′E	0		
J8/76/80	24/4/80	38°31.3′S	179°37.2′E	150		
J8/77/80	24/4/80	38°32.57′S	179°37.24′E	100		2013–2042
J8/79/80	24/4/80	38°32.98′S	179°36.32′E	30		
J11/102/80	23/8/80	42°23.7′S	169°55.26′E		1144	1927
I10/81	25/6/81	35°38′S	175°37′E	55		2140–2345

*Surface plankton trawl.

INDEX TO SPECIES

Numerals in **bold type** refer to illustrations

Abralia, 5, **25**, 31–37, 47
A. astrolineata, 6, 31–35 (**32**, **33**, **34**, **35**), 36, 47, 48
A. astrosticta, 33
A. gilchristi, 42
A. grimpei, 36
A. n.sp., 6, 35–36 (**35**), 37, 47
A. redfieldi, 35
A. sp. A, 6
A. sp. B, 6, 36–37 (**37**), 47
A. (Stenabralia), 6
Abraliopsis, 5, 6, 35, 37–46 (**41**), 47
A. (Abraliopsis), 41
A. felis, 41
A. gilchristi, 6, 42–46 (**44**, **45**, **46**), 47
A. hoylei, 6, 37, 42
A. neozealandica, 42
A. neozelanica, 42
A. n.sp., 6 (*see also A. tui*)
A. pfefferi, 41, 42
A. tui, 37–42 (**38**, **40**), 43, 47 (*see also A.* n.sp.)
Ancistrocheirus, 5, 8–10 (**9**), **18**, 47
A. lesueuri, 5, 6, 10

Benthoteuthis megalops, 15

Charybditeuthis margaritifera, 15

Enigmoteuthis, 5
Enoploteuthis, 5, 22–30 (**25**), 37, 47
E. anapsis, 30
E. chunii, 30
E. galaxias, 6, 22–25 (**23**, **24**, **25**), 30, 43, 47, 48
E. higginsi, 30
E. jonesi, 29–30 (**30**), 47
E. margaritifera, 15
E. neozelanica, 6, 42, 43
E. octolineata, 29
E. reticulata, 6, 25–29 (**26**, **27**, **28**), 47, 48
Euoploteuthis galaxias, 22

Lycoteuthis diadema, 6, 25

Micrabralia, 43

Onychoteuthis, 6

Pterygioteuthis, 5, 15–22 (**18**), 47
P. gemmata, 6, 15, 16, 17–18, **19**, **20**, 21 (**21**), 22, 47, 48
P. giardi, 5, 6, 15–16 (**16**), **17**, 18, 21, 47
P. margaritifera, 15
P. microlampas, 6, 16, 18–22 (**20**, **21**), 47
Pyroteuthis, 5, 10–15 (**14**), 47
P. addolux, **13**, 14, 15
P. margaritifera, 11, 13 (**13**), 14 (**14**), 15, 47
P. n.sp., 6
P. (Pterygioteuthis) giardi, 15
P. serrata, 10–15 (**12**, **13**), 47
P. sp., 6

Thelidioteuthis, 5, 10
T. alessandrinii, 10

Watasenia, 5, 35
W. scintillans, 5, 43

V. R. WARD, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1985

34794D—85PT

Bulletins of the Fisheries Research Division

No.

1. The New Zealand Cetacea. By D. E. Gaskin. Published in 1968. 92 p.
2. *Galaxias maculatus* (Jenyns), the New Zealand whitebait. By R. M. McDowall. Published in 1968. 84 p.
3. Phytoplankton productivity in Tomahawk Lagoon, Lake Waipori, and Lake Mahinerangi. By S. F. Mitchell. Published in 1971. 87 p.
4. Some aspects of the bionomics of fish in a brown trout nursery stream. By C. L. Hopkins. Published in 1970. 38 p.
5. Reproduction, early life history, and age-growth relationships of the New Zealand pilchard, *Sardinops neopilchardus* (Steindachner). By Alan N. Baker. Published in 1972. 64 p.
6. The biology of the New Zealand tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider). By L. J. Tong and C. M. Vooren. Published in 1972. 60 p.
7. An analysis of the statistics on the fishery for tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider), in New Zealand waters from 1936 to 1969, with notes on the trawl fishery in general. By C. M. Vooren. Published in 1974. 44 p.
8. Lakes Rotorua and Rotoiti, North Island, New Zealand: Their trophic status and studies for a nutrient budget. By G. R. Fish. Published in 1975. 72 p.
9. A survey of the tarakihi, *Cheilodactylus macropterus* (Bloch and Schneider), in the East Cape area, New Zealand, 26–30 March 1971. By C. M. Vooren and L. J. Tong. Published in 1973. 28 p.
10. The relation between primary productivity, nutrients, and the trout environment in some New Zealand lakes. By A. M. R. Burnet and Denise A. Wallace. Published in 1973. 28 p.
11. Biology and distribution of the toheroa, *Paphies (mesodesma) ventricosa* (Gray). By P. Redfearn. Published in 1974. 51 p.
12. Studies on age and growth, reproduction, and population dynamics of red gurnard, *Chelidonichthys kumu* (Lesson and Garnot), in the Hauraki Gulf, New Zealand. By R. D. Elder. Published in 1976. 77 p.
13. A study on age, growth, and population structure of the snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. By L. J. Paul. Published in 1976. 62 p.
14. Variations in growth, mortality, and population density of snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. By C. M. Vooren and R. F. Coombs. Published in 1977. 32 p.
15. The commercial fishery for snapper, *Chrysophrys auratus* (Forster), in the Auckland region, New Zealand, from 1900 to 1971. By L. J. Paul. Published in 1977. 84 p.
16. A bibliography of the literature about New Zealand's marine and freshwater commercial fisheries, 1840–1975. By L. J. Paul. Published in 1979. 43 p.
17. Age, growth, and condition of the common river galaxias, *Galaxias vulgaris* Stokell, in the Glentui River, Canterbury, New Zealand. By P. L. Cadwallader. Published in 1978. 35 p.
18. Tagging experiments on the sand flounder, *Rhombosolea plebeia* (Richardson), in Canterbury, New Zealand, 1964 to 1966. By J. A. Colman. Published in 1978. 42 p.
19. The life history of *Neochanna apoda* Günther (Pisces: Galaxiidae). By G. A Eldon. Published in 1978. 44 p.
20. The ecology of whitebait migrations (Galaxiidae: *Galaxias* spp.). By R. M. McDowall and G. A. Eldon. Published in 1980. 171 p.
21. Hydrology and the quantitative distribution of planktonic eggs of some marine fishes of the Otago coast, south-eastern New Zealand. By D. A. Robertson. Published in 1980. 69 p.
22. The number of snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand, based on egg surveys in 1974–75 and 1975–76. By J. Crossland. Published in 1980. 38 p.
23. Fish eggs and larvae of the Hauraki Gulf, New Zealand. By J. Crossland. Published in 1981. 61 p.
24. Distribution and abundance of fish eggs and larvae from the spring and summer plankton of north-east New Zealand, 1976–78. By J. Crossland. Published in 1982. 59 p.
25. Trevally, *Caranx georgianus* Cuvier: age determination, population biology, and the fishery. By G. D. James. Published in 1984. 51 p.
26. Allelic variation and fisheries management. By R. W. Gauldie. Published in 1984. 35 p.
27. The Enoploteuthidae (Cephalopoda: Oegopsida) of the New Zealand region. By D. J. Riddell. Published in 1985. 52 p.